TD-01-026

Quench Simulation of VLHC Transmission Line Magnet

(Task 2)

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Volodja,

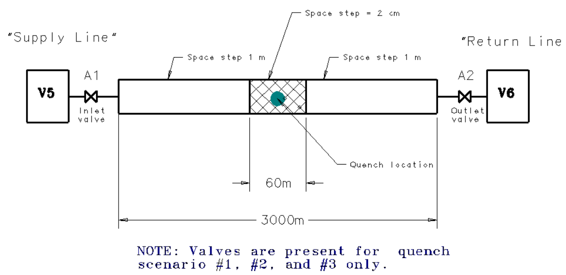
We would like to ask Dr.N.A.Shatil to simulate four more quench scenarios for two different hydraulic schemes. We also would like to change the initial temperature for helium (Tsl) from 4.52K to 5.6K,
and add more copper to the pipe. Below, is a list of particular changes:

RE: Initial State

?? Change initial temperature of helium (Tsl) from 4.52K to 5.6K.

RE: Space and time discretization

?? Use different node size for different sections of the conductor central channel. For the center section of 60 m where quench will be initiated use space step of 2 cm. For two other sections use one meter nodes(see picture below for reference).



RE: Hydraulic scheme

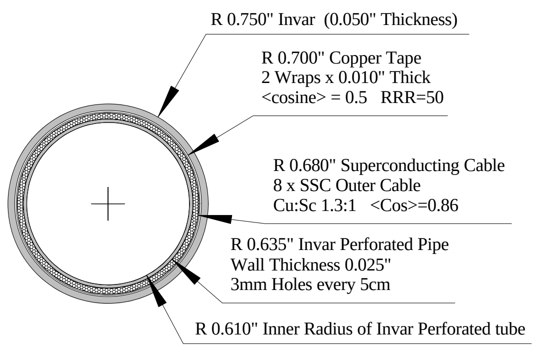
?? Change the conductor central channel length from 60 m to 3km(quench scenario 1,2, and 3)
?? Change the conductor central channel length from 60 m to 375m(quench scenario 4)

RE: Quench scenario

1. Single point(3 cm) quench ,and the new hydraulic scheme and initial state(3000m and 5.6K);
2. Twenty(20) meters quench ,and the new hydraulic scheme and initial state(3000m and 5.6K);
3. Twenty(20) meters quench ,and the new hydraulic scheme (3000m) with initial temperature of 4.6K;
4. Twenty(20) meters quench every 375m simulated with periodic boundary conditions.

RE: Cable Geometry and Material utilized

Please correct the cable geometry according to the sketch below.



Arkadiy (x8357)

Option 1: L=3000 m, $l_{disturbance}$=3 cm (located in center of conductor with two layers of Rutherford cable)
Initial conditions: P_{in}=3.3 bar, T_{in}=5.6 K, dm/dt=40 g/s, Q_{ext}=0 W/m
Conductor model: conductor is divided into three parts: 1490+20+1490 m. Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 1 cm (other ones use 1m space step and utilize 1D approach for tubes)

Option 2: L=3000 m, $l_{disturbance}$=20 m (located in the center of conductor with two layers of Rutherford cable)
Initial conditions: P_{in}=3.3 bar, T_{in}=5.6 K, dm/dt=40 g/s, Q_{ext}=0 W/m
Conductor model: conductor is divided into three parts: 1450+100+1450 m. Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 2 cm (other ones use 1m space step and utilize 1D approach for tubes)

Option 3: L=3000 m, $l_{disturbance}$=20 m (located in of conductor with two layers of Rutherford cable)
Initial conditions: P_{in}=3.3 bar, T_{in}=4.6 K, dm/dt=40 g/s, Q_{ext}=0 W/m
Conductor model: conductor is divided into three parts: 1450+100+1450 m. Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 2 cm (other ones use 1m space step and utilize 1D approach for tubes)

Option 4: L=375 m (with closed ends for simulating of periodic condition), $l_{disturbance}$=20 m (located in the center of every 375 m conductor with two layers of Rutherford cable).
Initial conditions: P_{in}=3.3 bar, T_{in}=4.6 K, dm/dt=0 g/s, Q_{ext}=0 W/m
Conductor model: conductor is divided into three parts: 137.5+100+137.5 m. Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 2 cm (other ones use 0.1 m space step and utilize 1D approach for tubes)

Option 5: L=3000 m, $l_{disturbance}$=20 m (located of conductor with two layers of Rutherford cable). Current carrier copper is enlarged about twice.
Initial conditions: P_{in}=3.3 bar, T_{in}=4.6 K, dm/dt=40 g/s, Q_{ext}=0 W/m
Conductor model: conductor is divided into three parts: 1451+100+1451 m. Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 2 cm (other ones use 1m space step and utilize 1D approach for tubes)

Option 5a: L=3000 m, $l_{disturbance}$=50 m (located in center of conductor with two layers of Rutherford cable). Current carrier copper is enlarged about twice.
Initial conditions: P_{in}=3.3 bar, T_{in}=4.6 K, dm/dt=40 g/s, Q_{ext}=0 W/m
Conductor model: conductor is divided into three parts: 1425+150+1425 m. Central part utilizes the 3D model for the inner and outer invar tubes and uses a

space step 2 cm (other ones use 1m space step and utilize 1D approach for tubes)

Option 5b: L=3000 m, $l_{disturbance}$=100 m (located in center of conductor with two layers of Rutherford cable). Current carrier copper is enlarged about twice.
Initial conditions: P_{in}=3.3 bar, T_{in}=4.6 K, dm / dt=40 g / s, Q_{ext}=0 W / m
Conductor model: conductor is divided into three parts: 1375+300+1375 m.
Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 4 cm (other ones use 1m space step and utilize 1D approach for tubes)

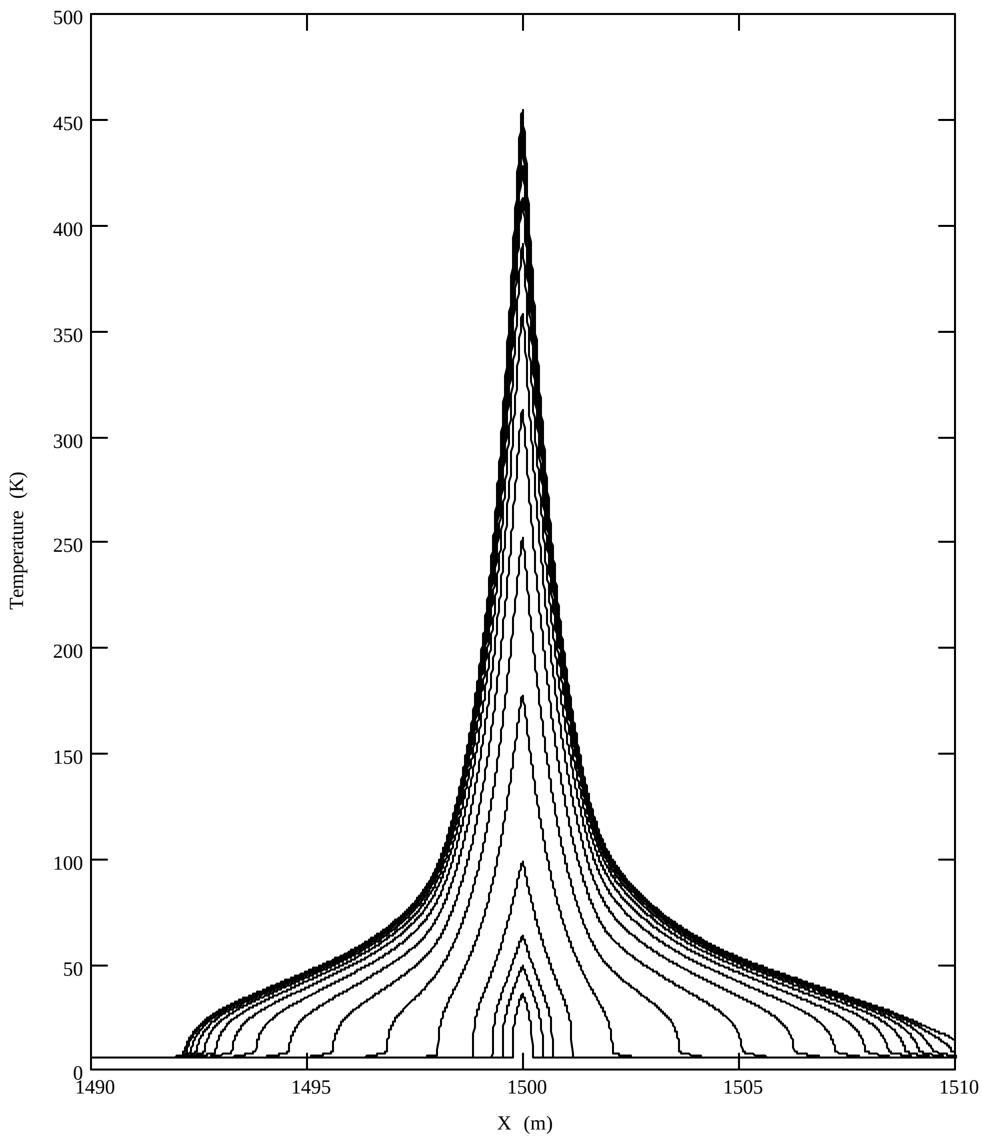
Option 6: L=3000 m, $l_{disturbance}$=50 m (located in center of conductor with two layers of Rutherford cable)
Initial conditions: P_{in}=3.3 bar, T_{in}=4.6 K, dm / dt=40 g / s, Q_{ext}=0 W / m
Conductor model: conductor is divided into three parts: 1425+150+1425 m.
Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 2 cm (other ones use 1m space step and utilize 1D approach for tubes)

Option 7: L=3000 m, $l_{disturbance}$=20 m (located in the center of conductor with two layers of Rutherford cable)
Initial conditions: P_{in}=5.0 bar, T_{in}=4.6 K, dm / dt=40 g / s, Q_{ext}=0 W / m
Conductor model: conductor is divided into three parts: 1450+100+1450 m.
Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 2 cm (other ones use 1m space step and utilize 1D approach for tubes)

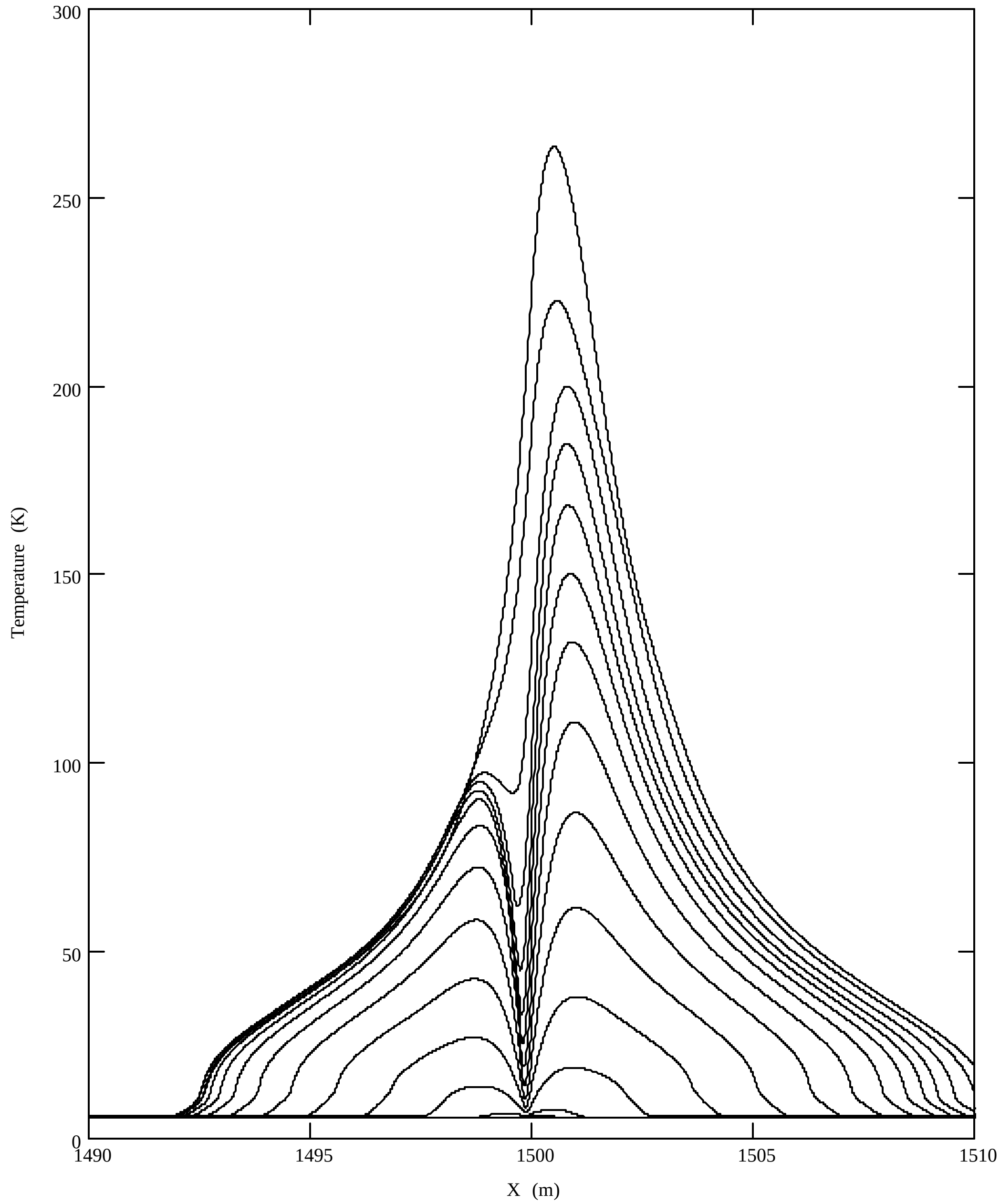
Option 1: L=3000 m, $l_{disturbance}$=3 cm (located in the center of conductor with two layers of Rutherford cable)

Initial conditions: P_{in}=3.3 bar, T_{in}=5.6 K, dm / dt=40 g / s, Q_{ext}=0 W / m

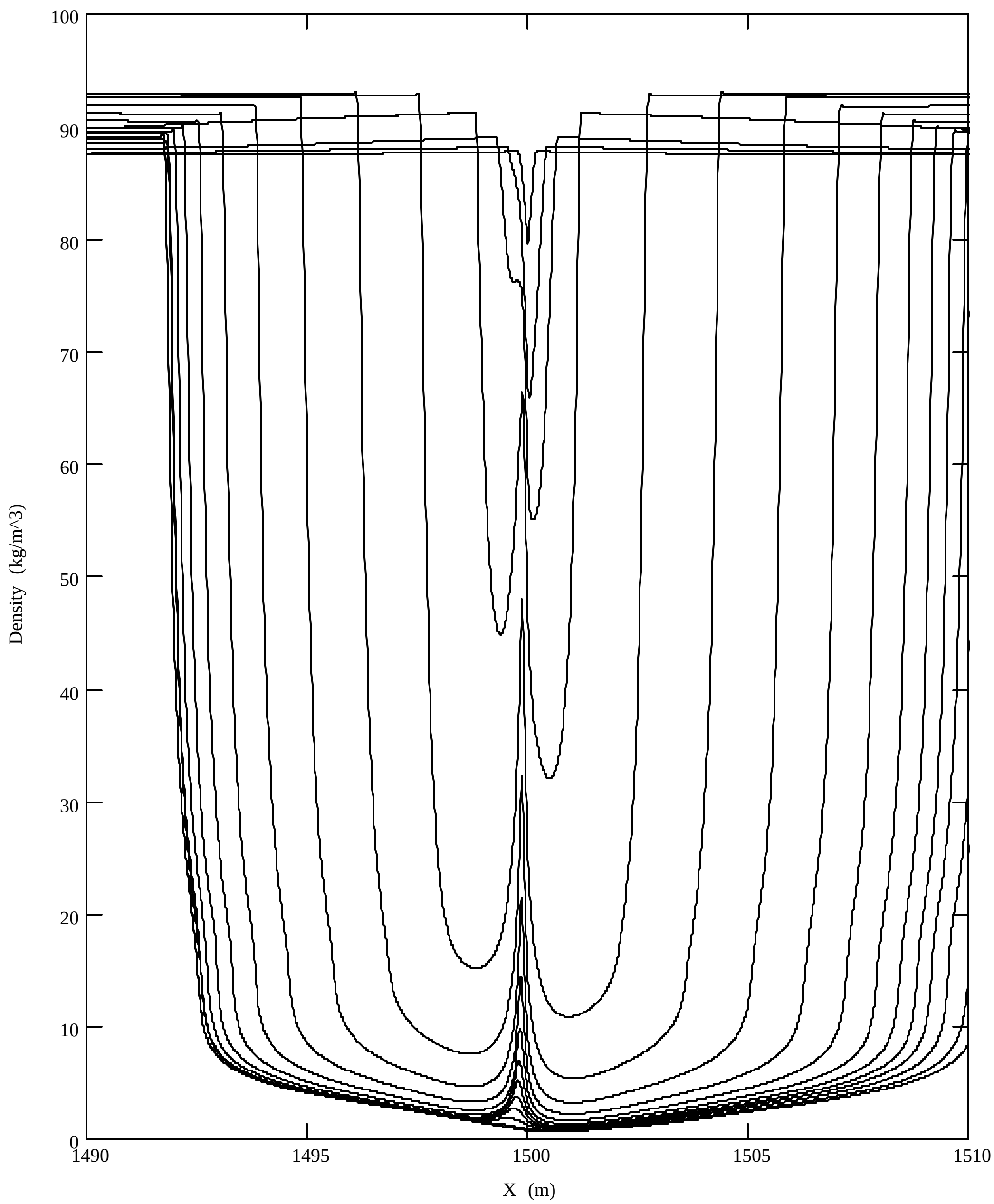
Conductor model: conductor is divided into three parts: 1490+20+1490 m. Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 1 cm (other ones use 1m space step and utilize 1D approach for tubes)



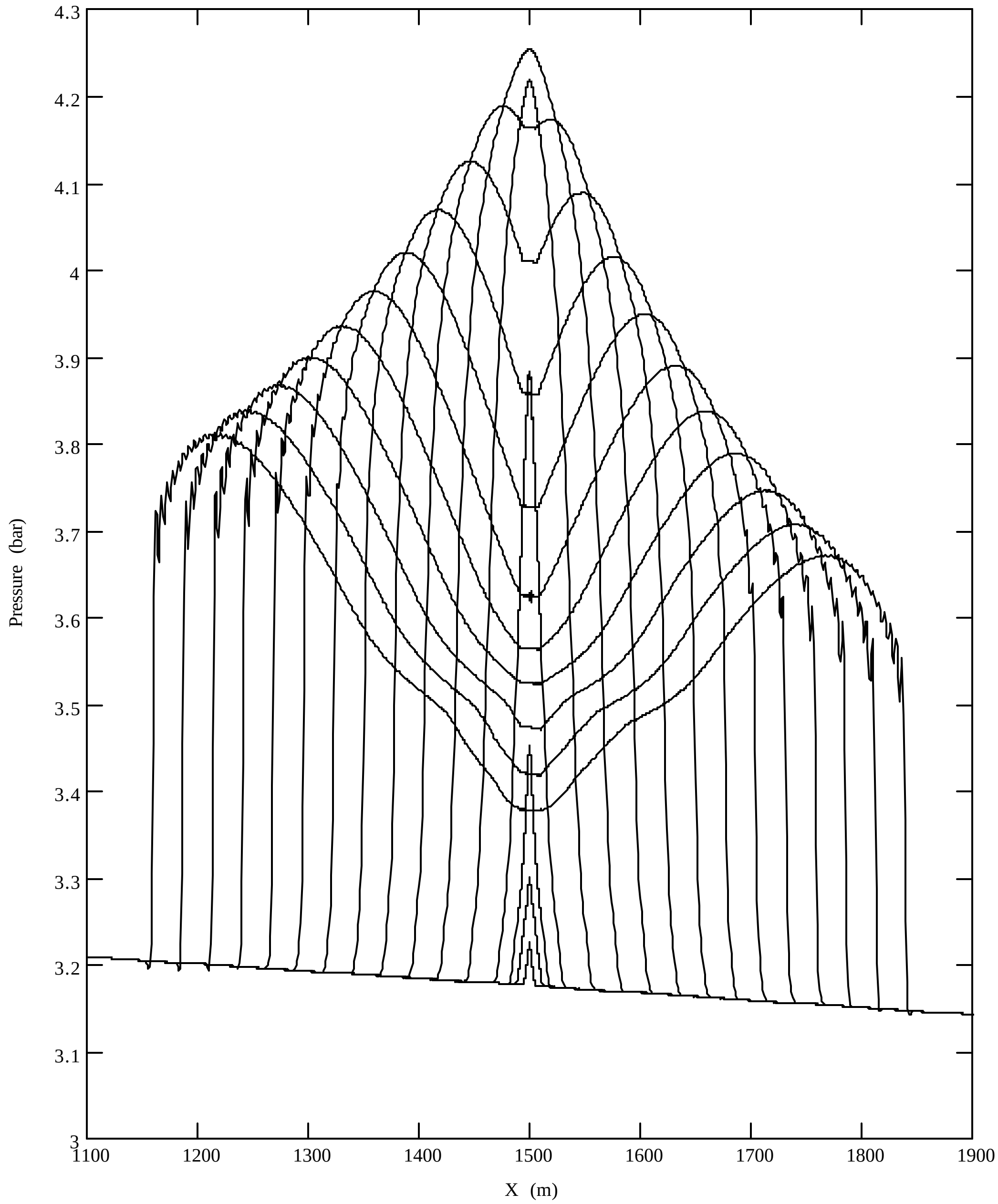
Evolution of the cable temperature. Times: 0.05, 0.1, 0.15, 0.25, 0.45, 0.65, 0.85, 1.05, 1.25, 1.45, 1.65, 1.85, 2.05, 2.25, 2.45, 2.65 s.



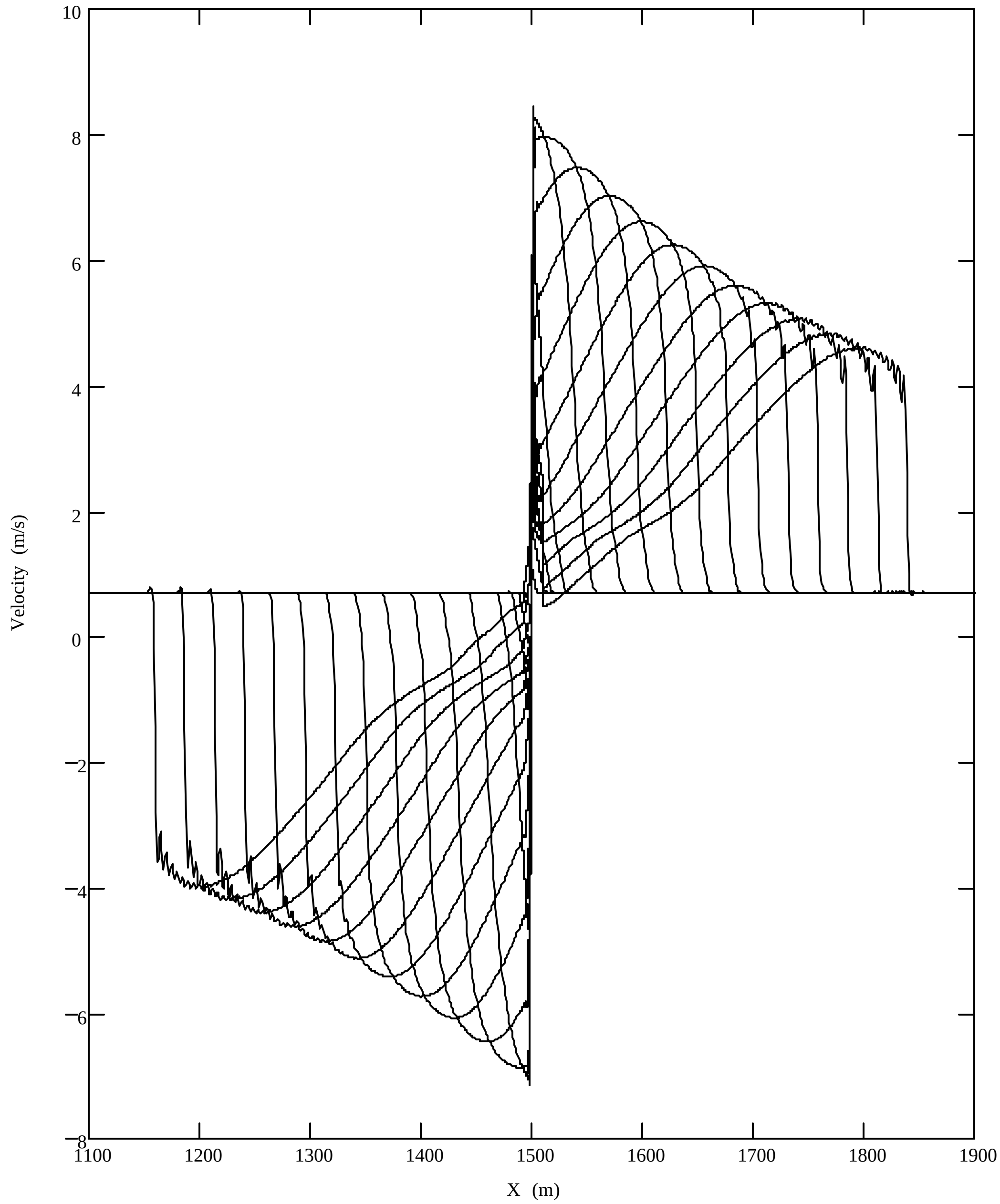
Evolution of the He temperature. Times: 0.05, 0.1, 0.15, 0.25, 0.45, 0.65, 0.85, 1.05, 1.25, 1.45, 1.65, 1.85, 2.05, 2.25, 2.45, 2.65 s.



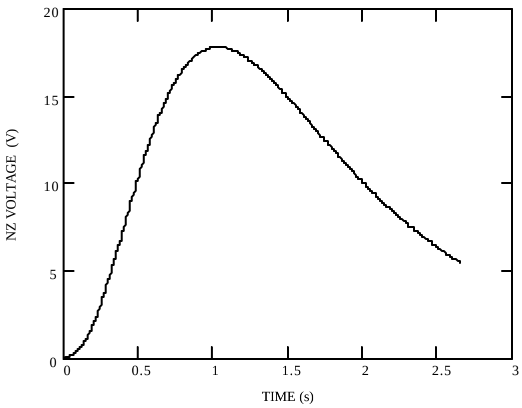
Evolution of the He density. Times: 0.05, 0.1, 0.15, 0.25, 0.45, 0.65, 0.85, 1.05, 1.25, 1.45, 1.65, 1.85, 2.05, 2.25, 2.45, 2.65 s.

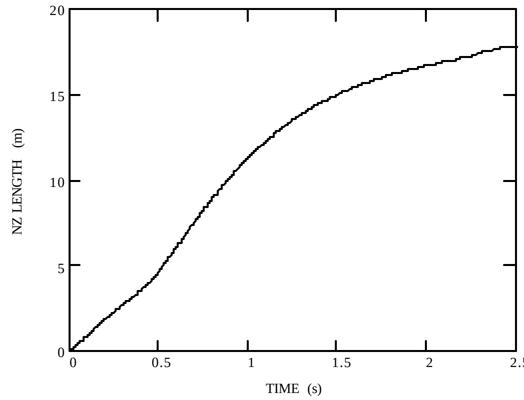


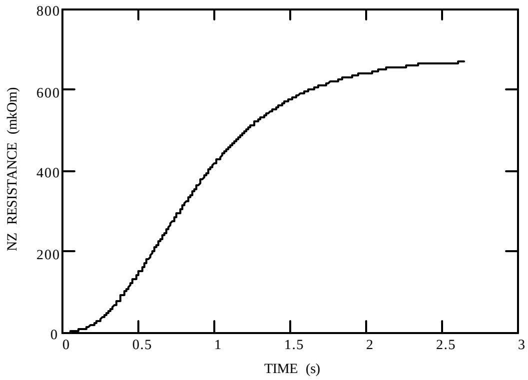
Evolution of the He pressure. Times: 0.05, 0.1, 0.15, 0.25, 0.45, 0.65, 0.85, 1.05, 1.25, 1.45, 1.65, 1.85, 2.05, 2.25, 2.45, 2.65 s.

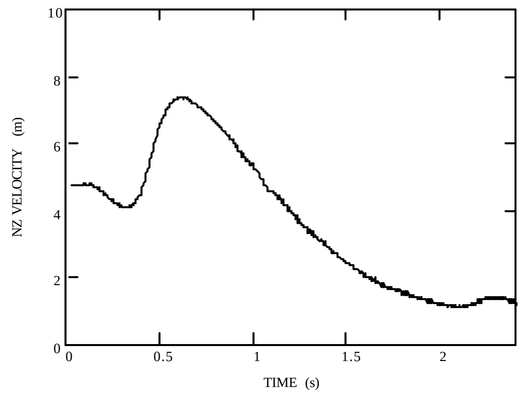


Evolution of the He velocity. Times: 0.05, 0.1, 0.15, 0.25, 0.45, 0.65, 0.85, 1.05, 1.25, 1.45, 1.65, 1.85, 2.05, 2.25, 2.45, 2.65 s.


NZ VOLTAGE (V)
TIME (s)
0
5
10
15
20
0
0.5
1
1.5
2
2.5
3


NZ LENGTH (m)
TIME (s)
0
5
10
15
20
0
0.5
1
1.5
2
2.5

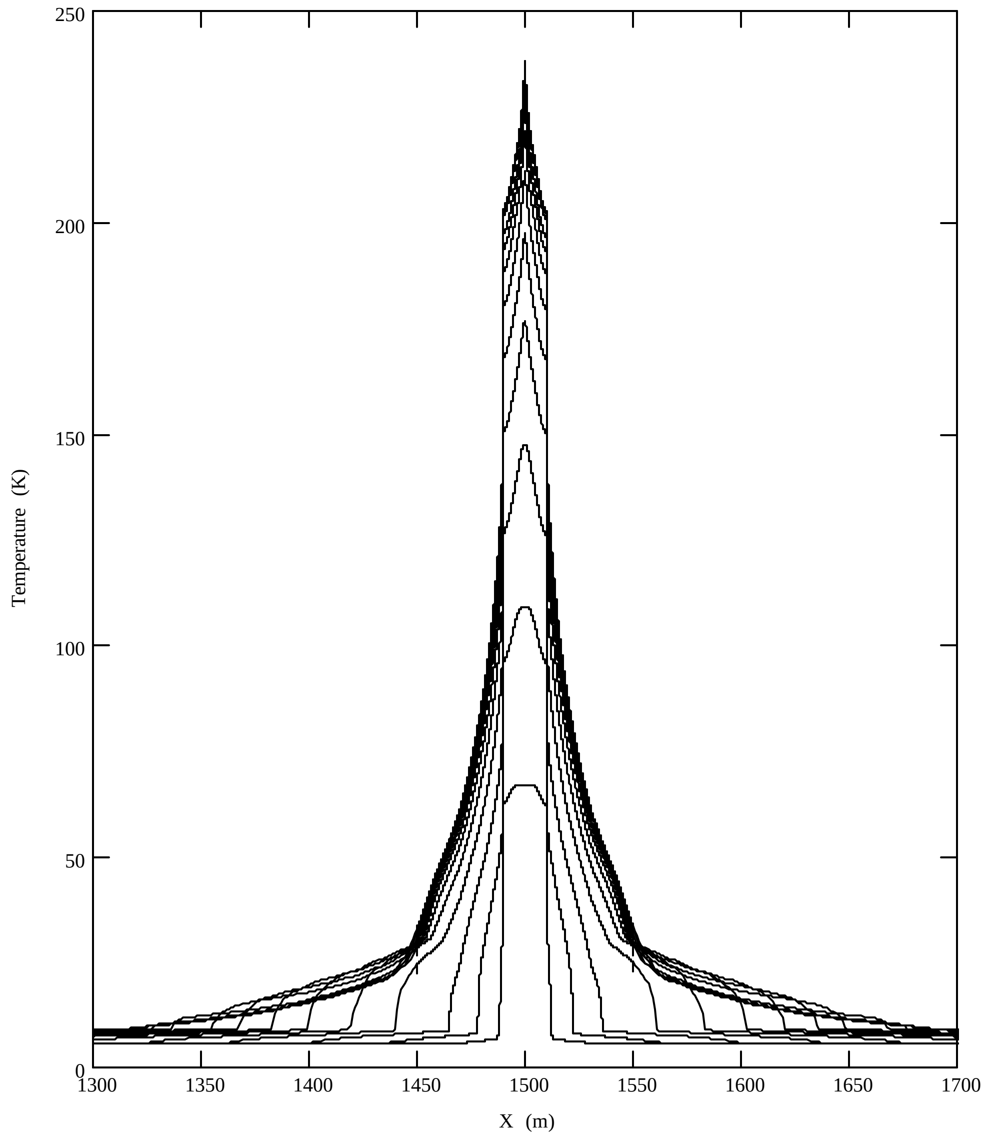

NZ RESISTANCE (mkOm)
TIME (s)
0
200
400
600
800
0
0.5
1
1.5
2
2.5
3


NZ VELOCITY (m)
TIME (s)
0
2
4
6
8
10
0
0.5
1
1.5
2

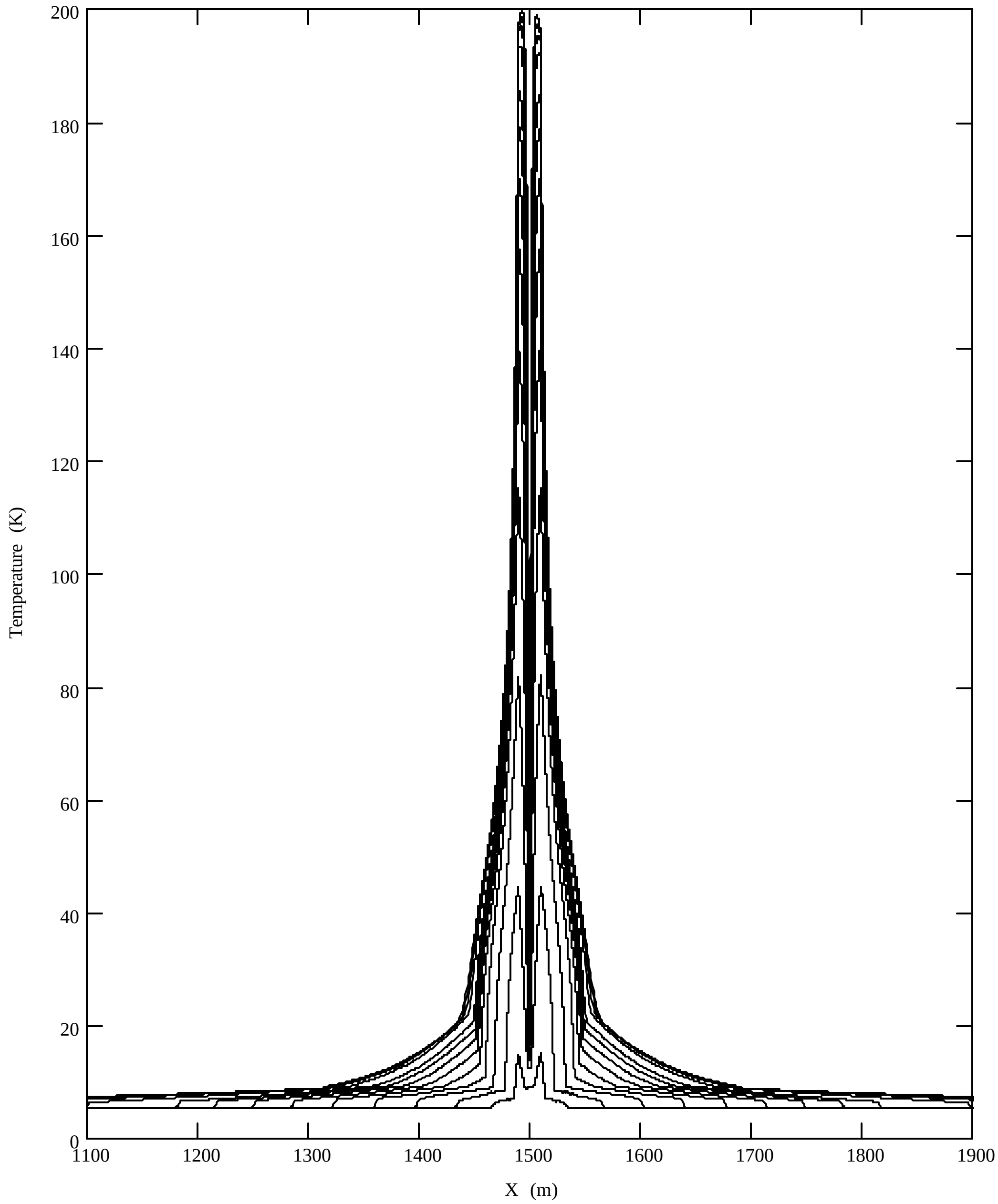
Option 2: L=3000 m, $l_{disturbance}$=20 m (located in the center of conductor with two layers of Rutherford cable)

Initial conditions: P_{in}=3.3 bar, T_{in}=5.6 K, dm / dt=40 g / s, Q_{ext}=0 W / m

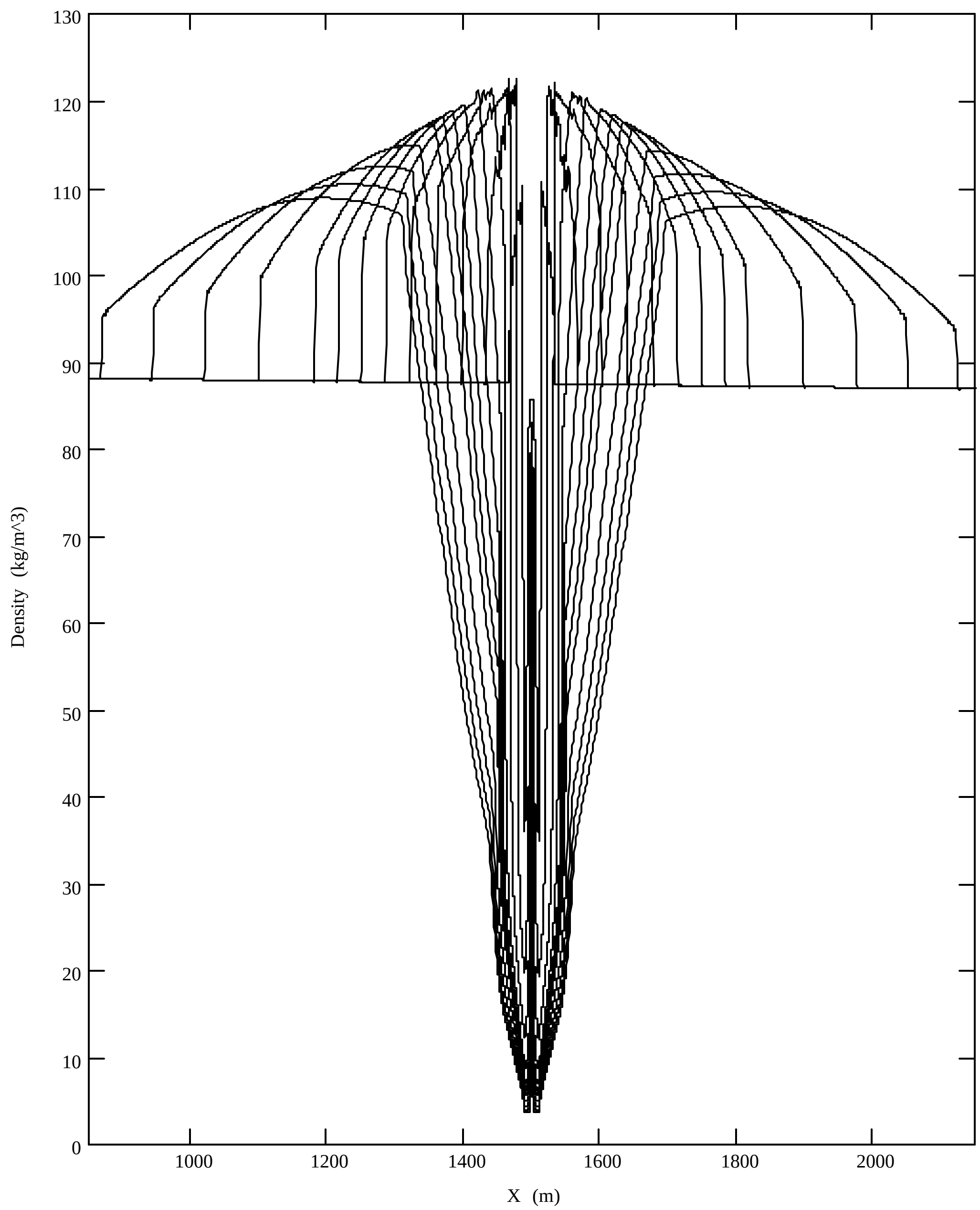
Conductor model: conductor is divided into three parts: 1450+100+1450 m. Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 2 cm (other ones use 1m space step and utilize 1D approach for tubes)



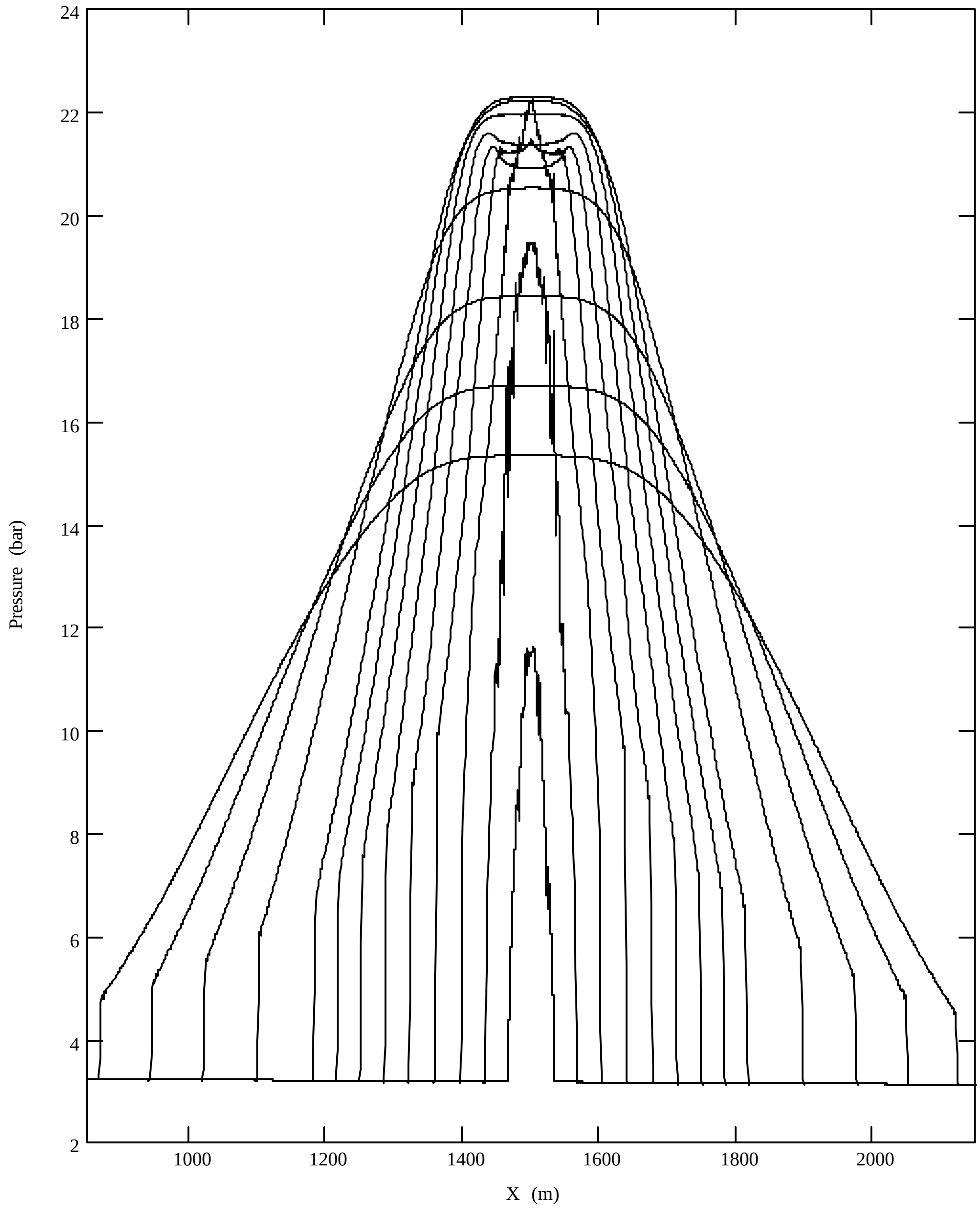
Evolution of the cable temperature. Times: 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.3, 2.5, 3.3, 3.8 s.



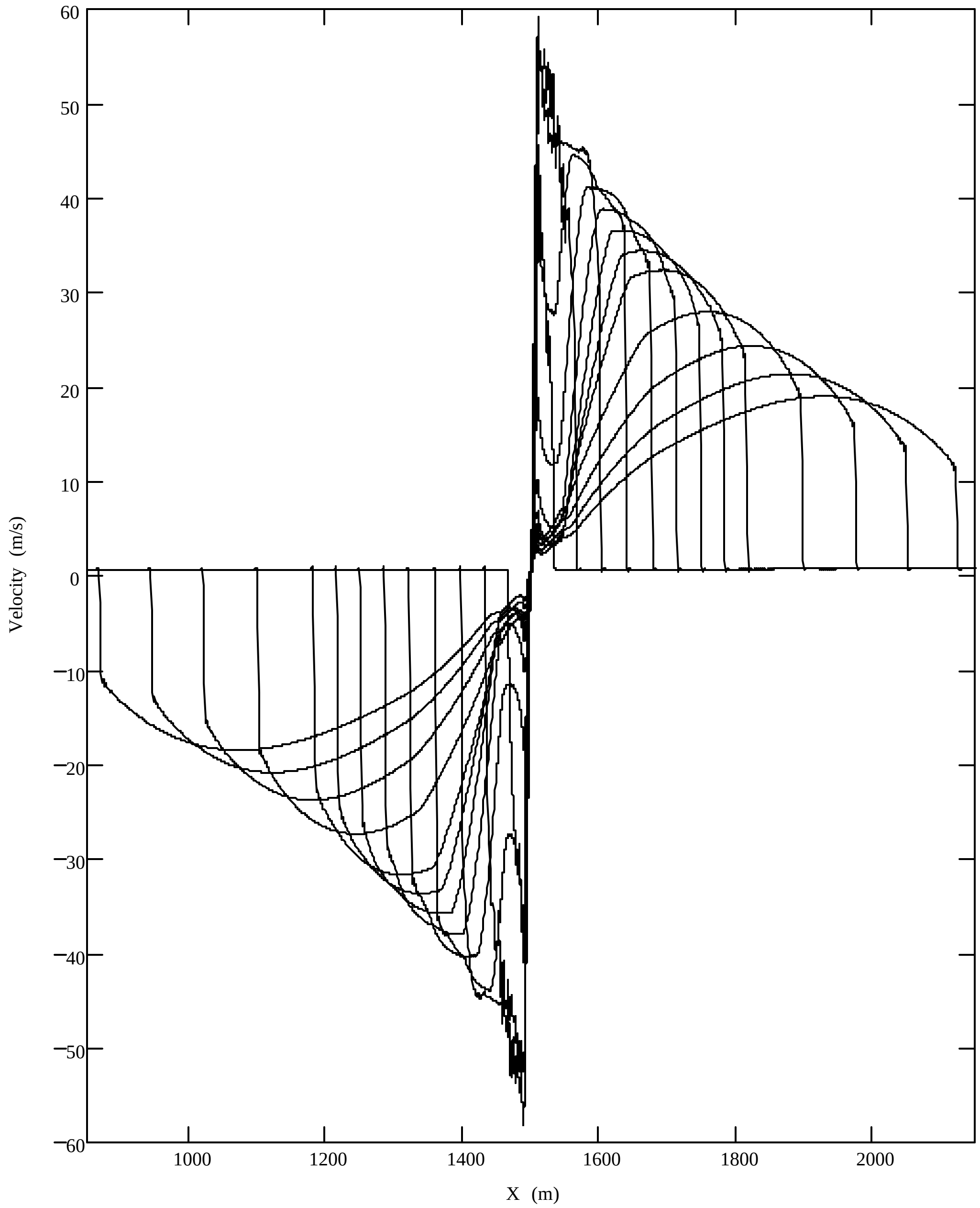
Evolution of the He temperature. Times: 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.3, 2.5, 3.3, 3.8 s.



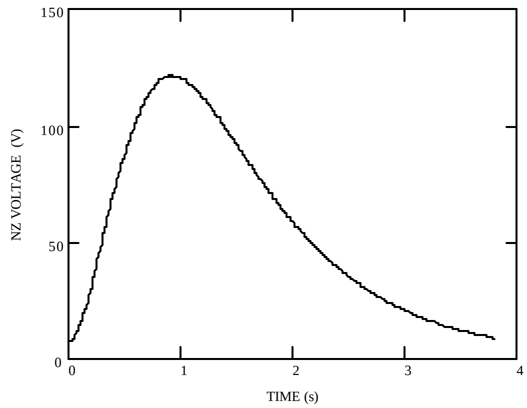
Evolution of the He density. Times: 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.3, 2.5, 3.3, 3.8 s.



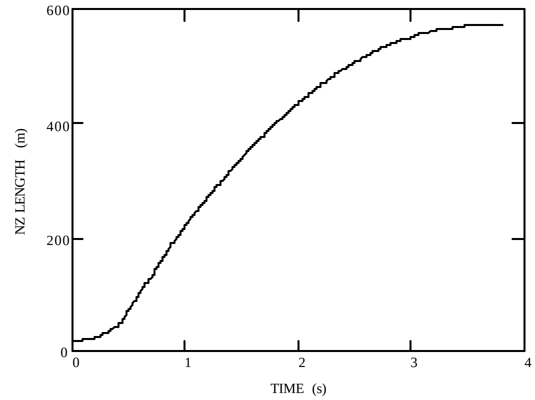
Evolution of the He pressure. Times: 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.3, 2.5, 3.3, 3.8 s.



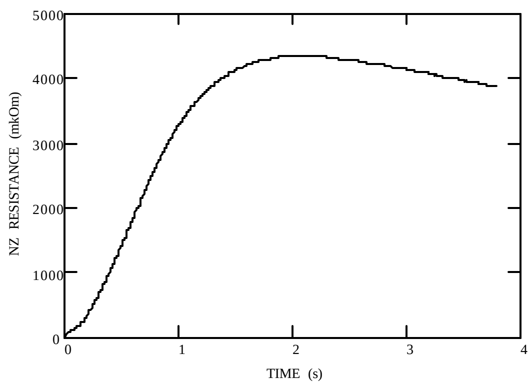
Evolution of the He velocity. Times: 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.3, 2.5, 3.3, 3.8 s.



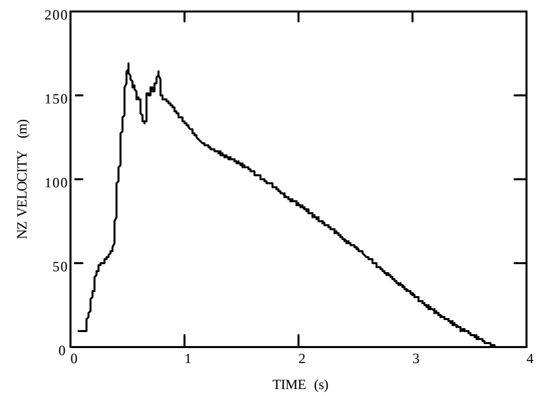
NZ VOLTAGE (V)
150
100
50
0
0
1
2
3
4
TIME (s)



NZ LENGTH (m)
600
400
200
0
0
1
2
3
4
TIME (s)

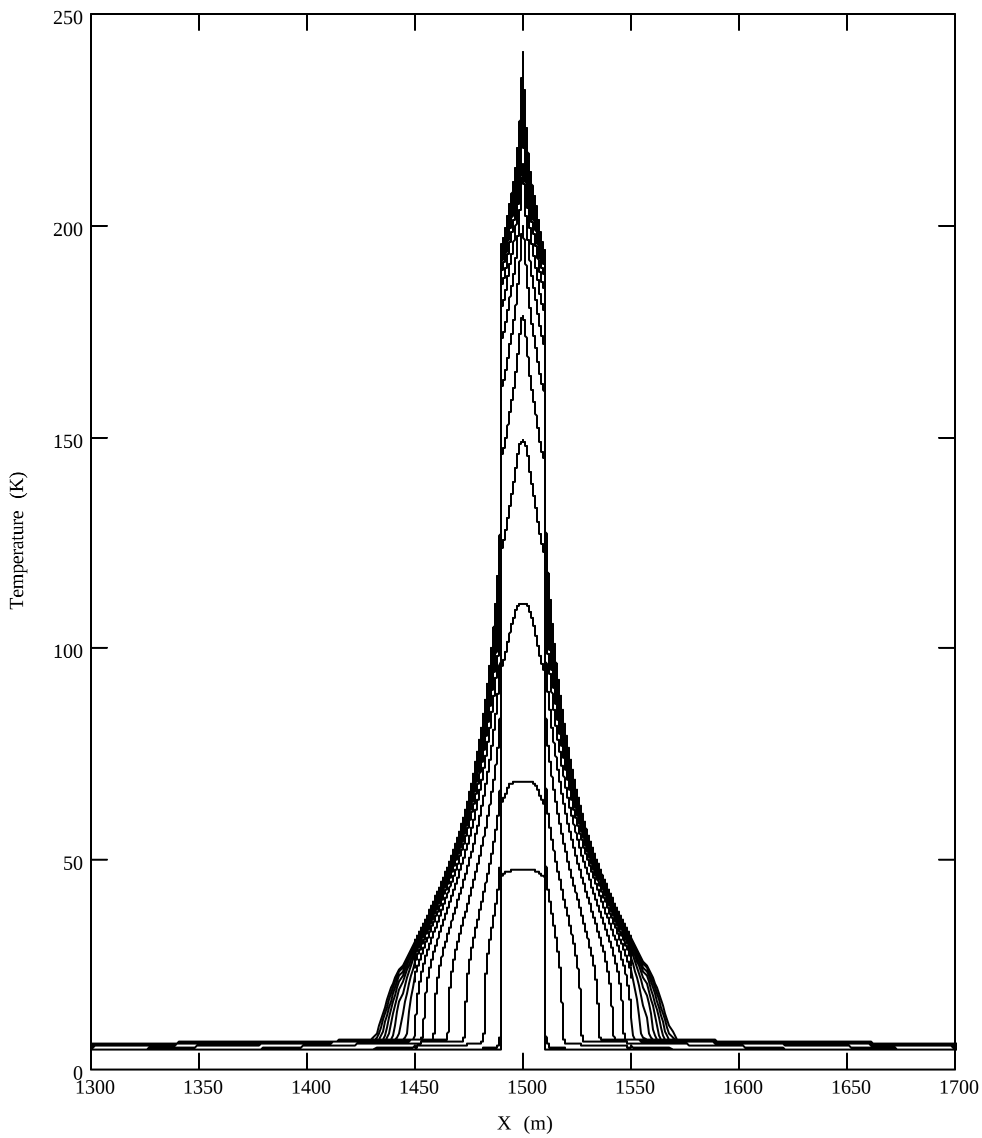


NZ RESISTANCE (mkOm)
5000
4000
3000
2000
1000
0
0
1
2
3
4
TIME (s)

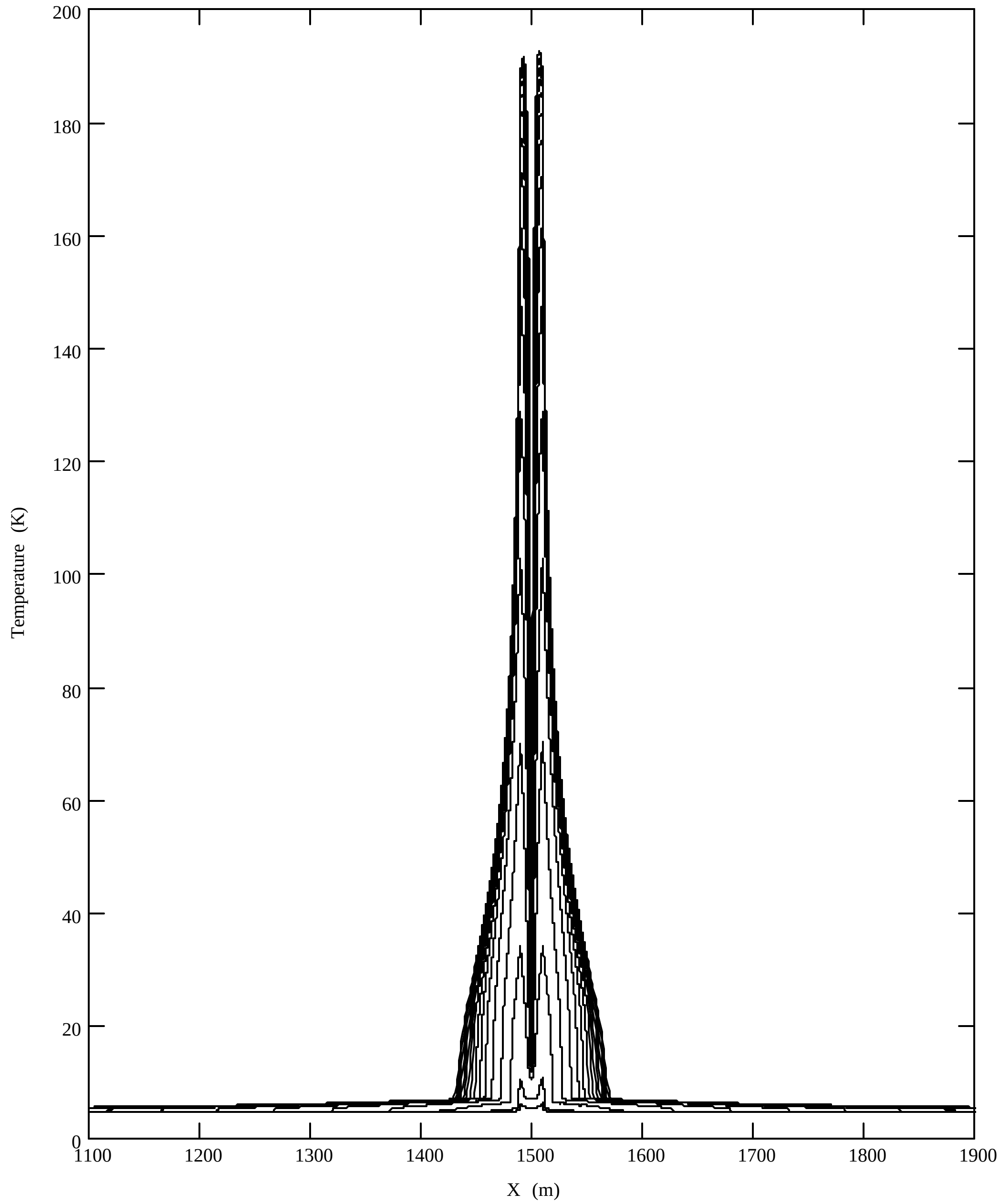


NZ VELOCITY (m)
200
150
100
50
0
0
1
2
3
4
TIME (s)

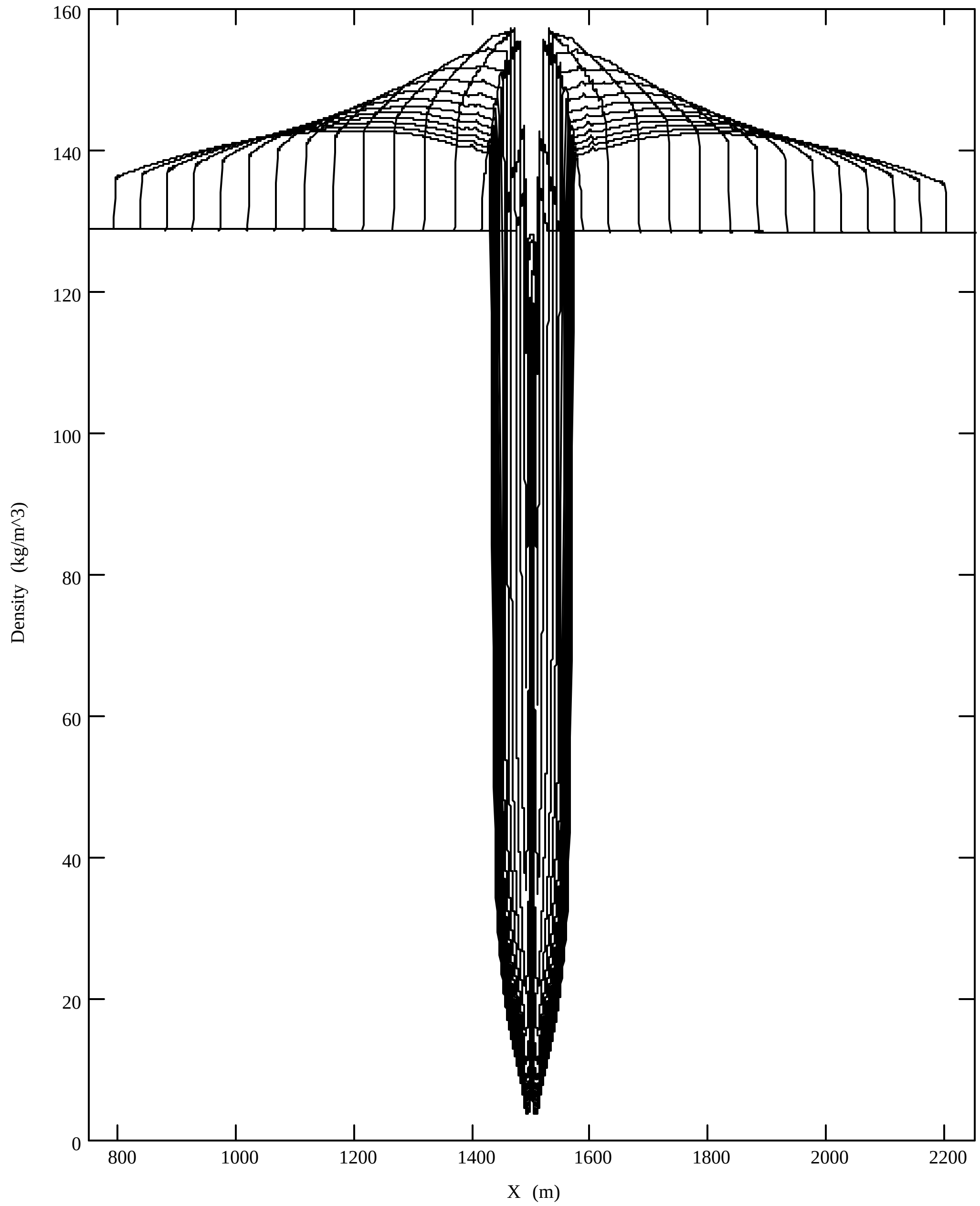
Option 3: L=3000 m, $l_{disturbance}$=20 m (located in the center of conductor with two layers of Rutherford cable)
Initial conditions: P_{in}=3.3 bar, T_{in}=4.6 K, dm / dt=40 g / s, Q_{ext}=0 W / m
Conductor model: conductor is divided into three parts: 1450+100+1450 m. Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 2 cm (other ones use 1m space step and utilize 1D approach for tubes)



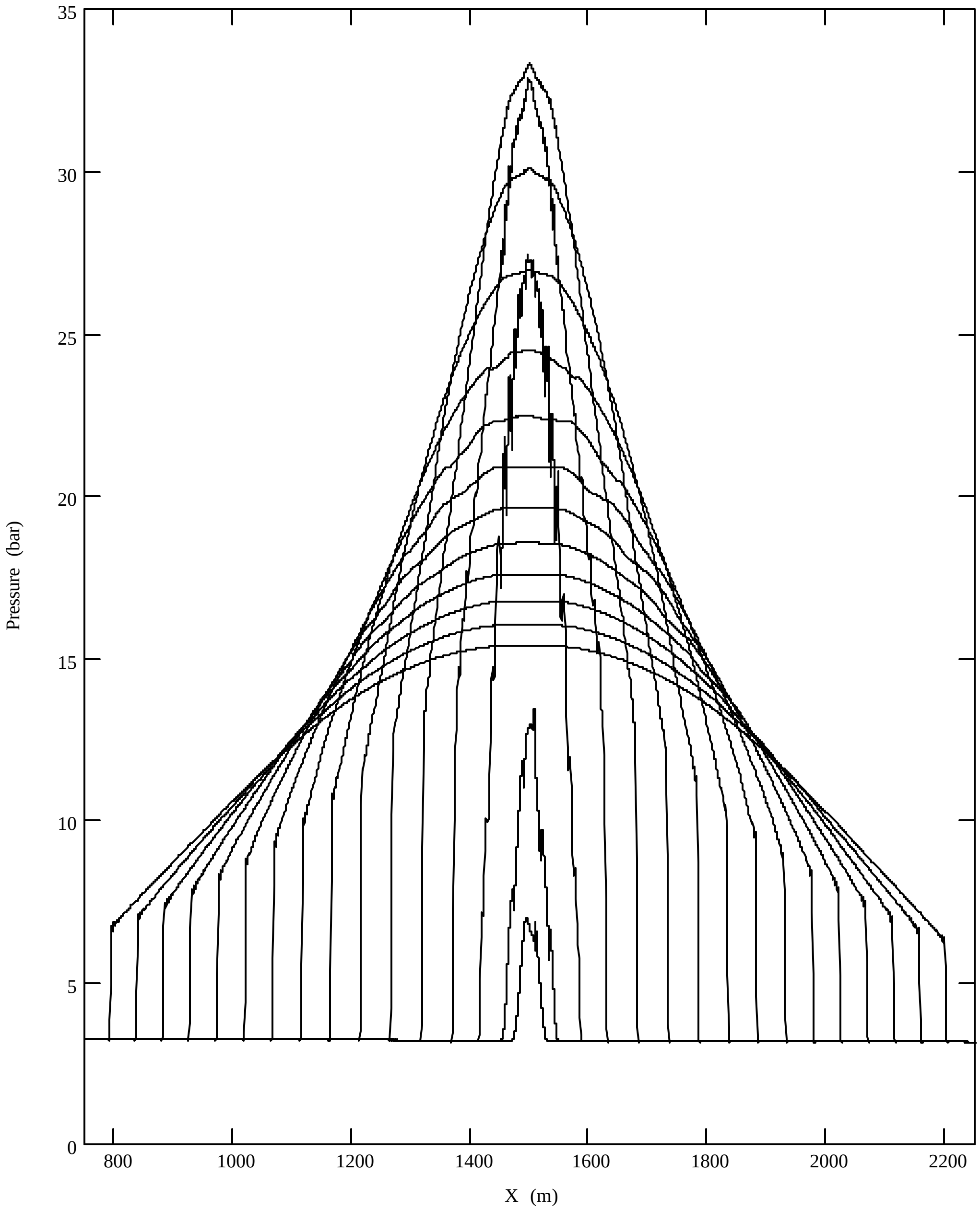
Evolution of the cable temperature. Times: 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0 s.



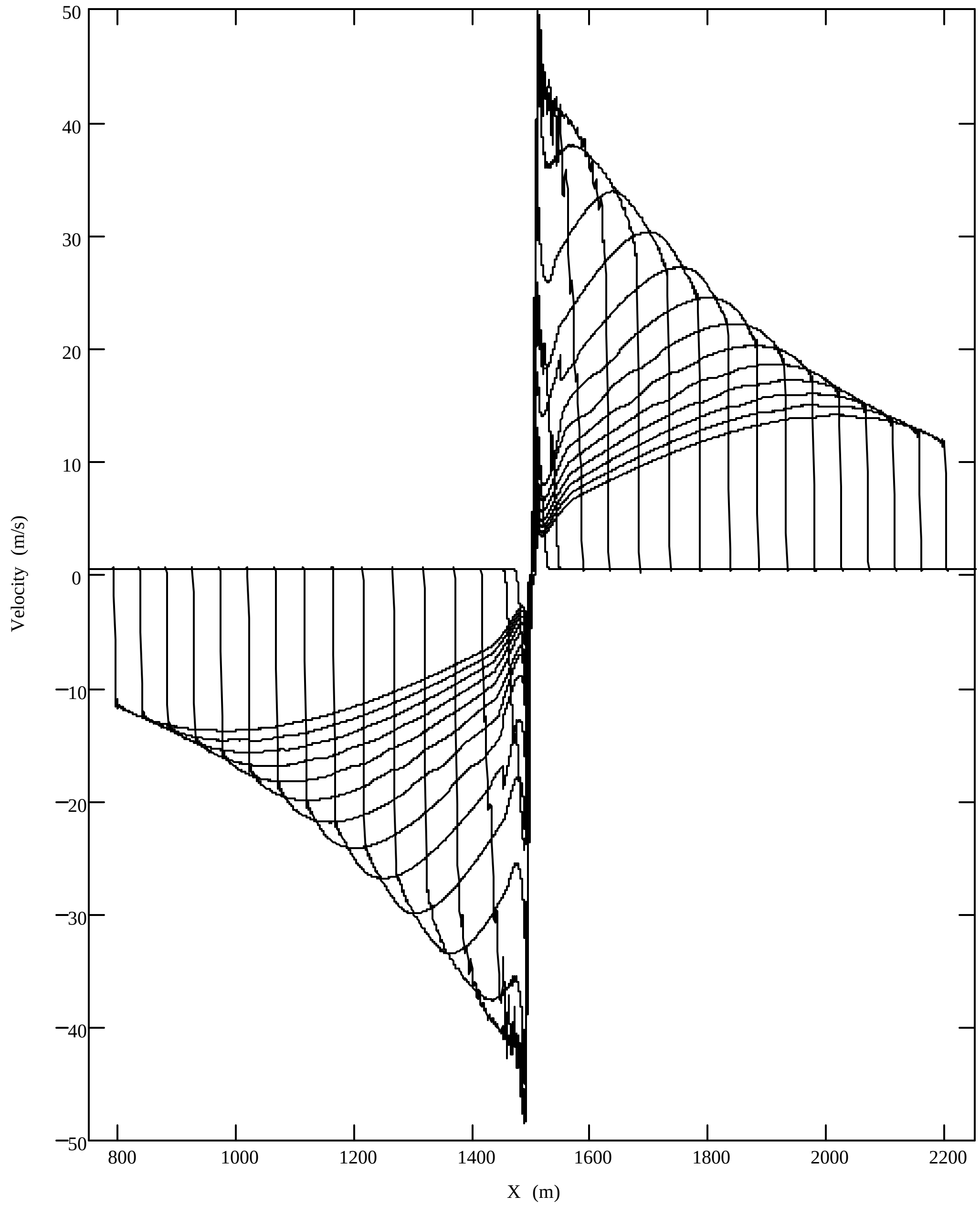
Evolution of the He temperature. Times: 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0 s.



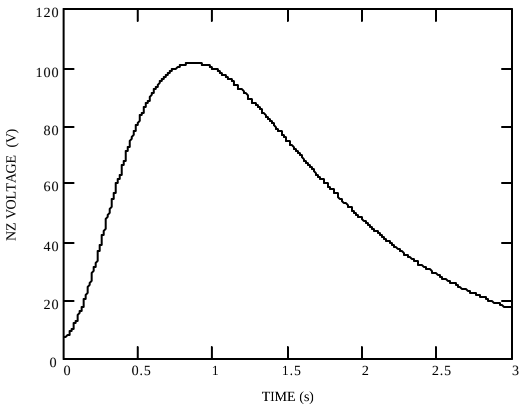
Evolution of the He density. Times: 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0 s.

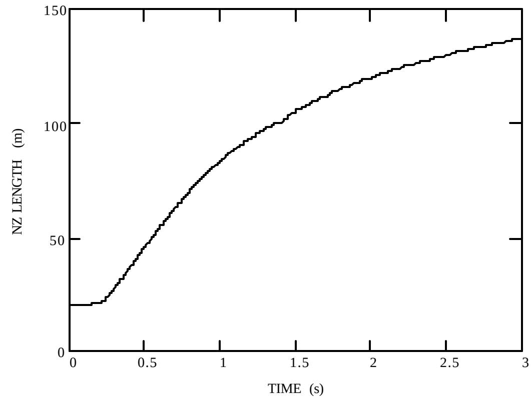


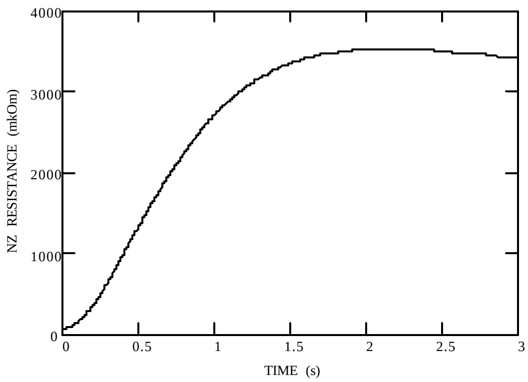
Evolution of the He pressure. Times: 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0 s.

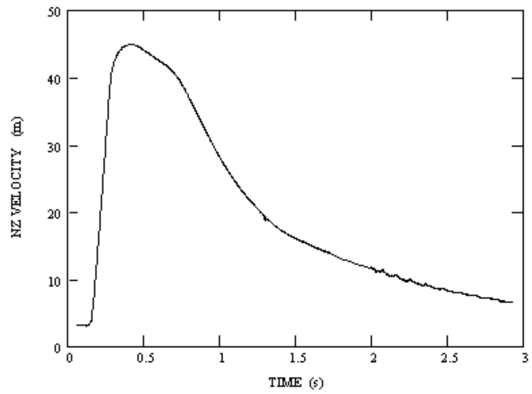


Evolution of the He velocity. Times: 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0 s.

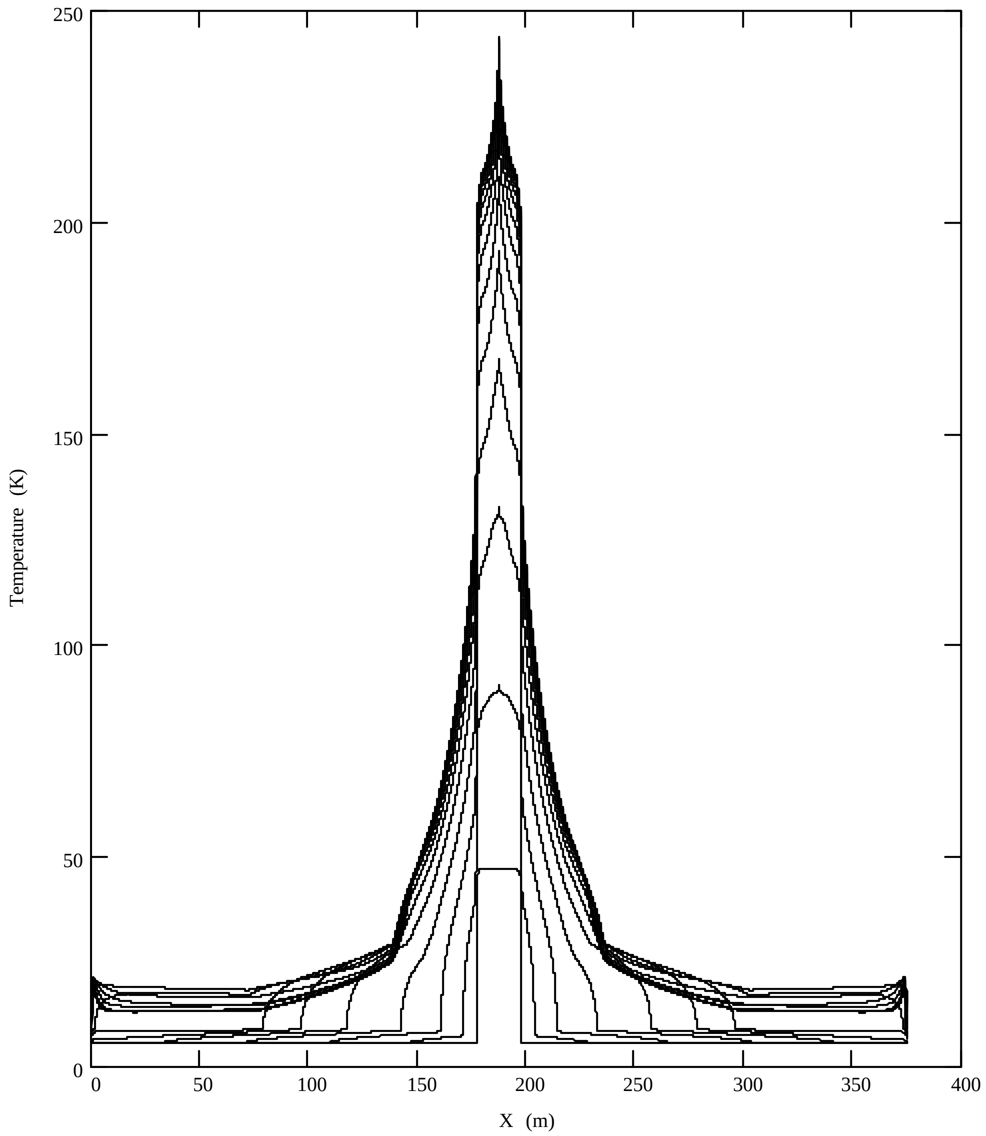

NZ VOLTAGE (V)
TIME (s)
0
20
40
60
80
100
120
0
0.5
1
1.5
2
2.5
3


NZ LENGTH (m)
TIME (s)
0
50
100
150
0
0.5
1
1.5
2
2.5
3

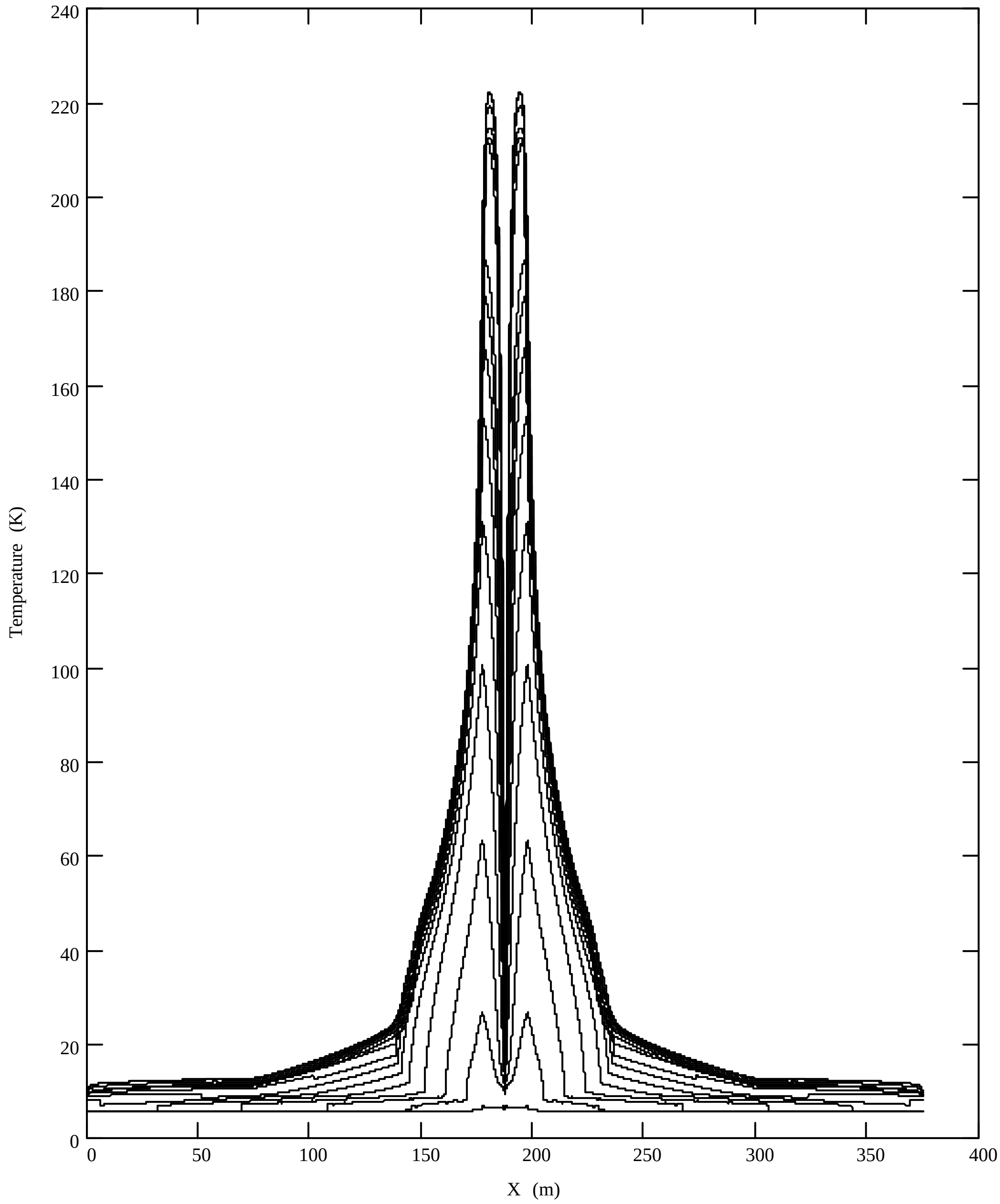

NZ RESISTANCE (mkOm)
TIME (s)
0
1000
2000
3000
4000
0
0.5
1
1.5
2
2.5
3


NZ VELOCITY (m)
TIME (s)
0
10
20
30
40
50
0
0.5
1
1.5
2
2.5
3

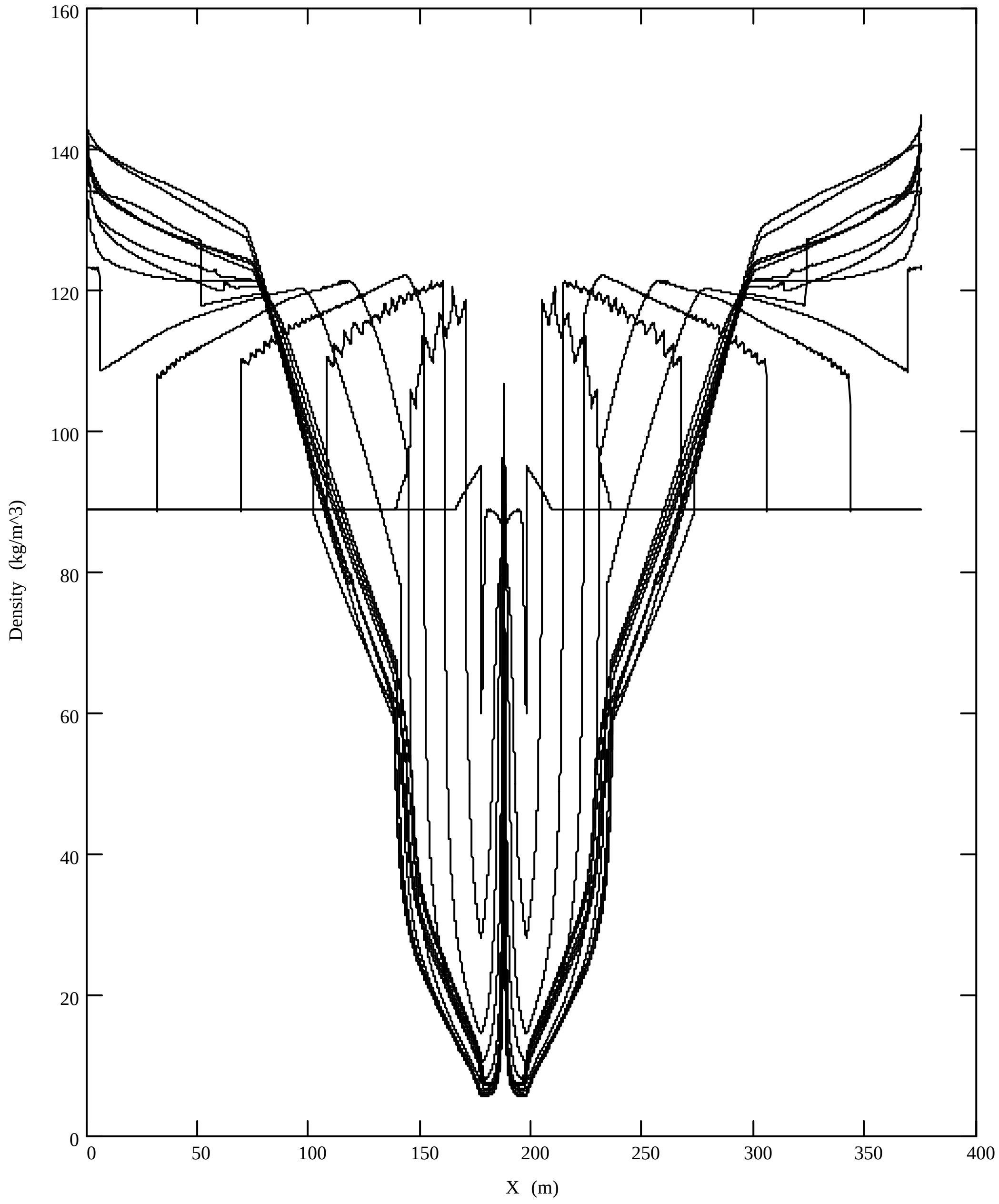
Option 4: L=375 m (with closed ends for simulating of periodic condition), $l_{disturbance}$=20 m (located in the center of every 375 m conductor with two layers of Rutherford cable).
Initial conditions: P_{in}=3.3 bar, T_{in}=4.6 K, dm / dt=0 g / s, Q_{ext}=0 W / m
Conductor model: conductor is divided into three parts: 137.5+100+137.5 m. Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 2 cm (other ones use 0.1 m space step and utilize 1D approach for tubes)



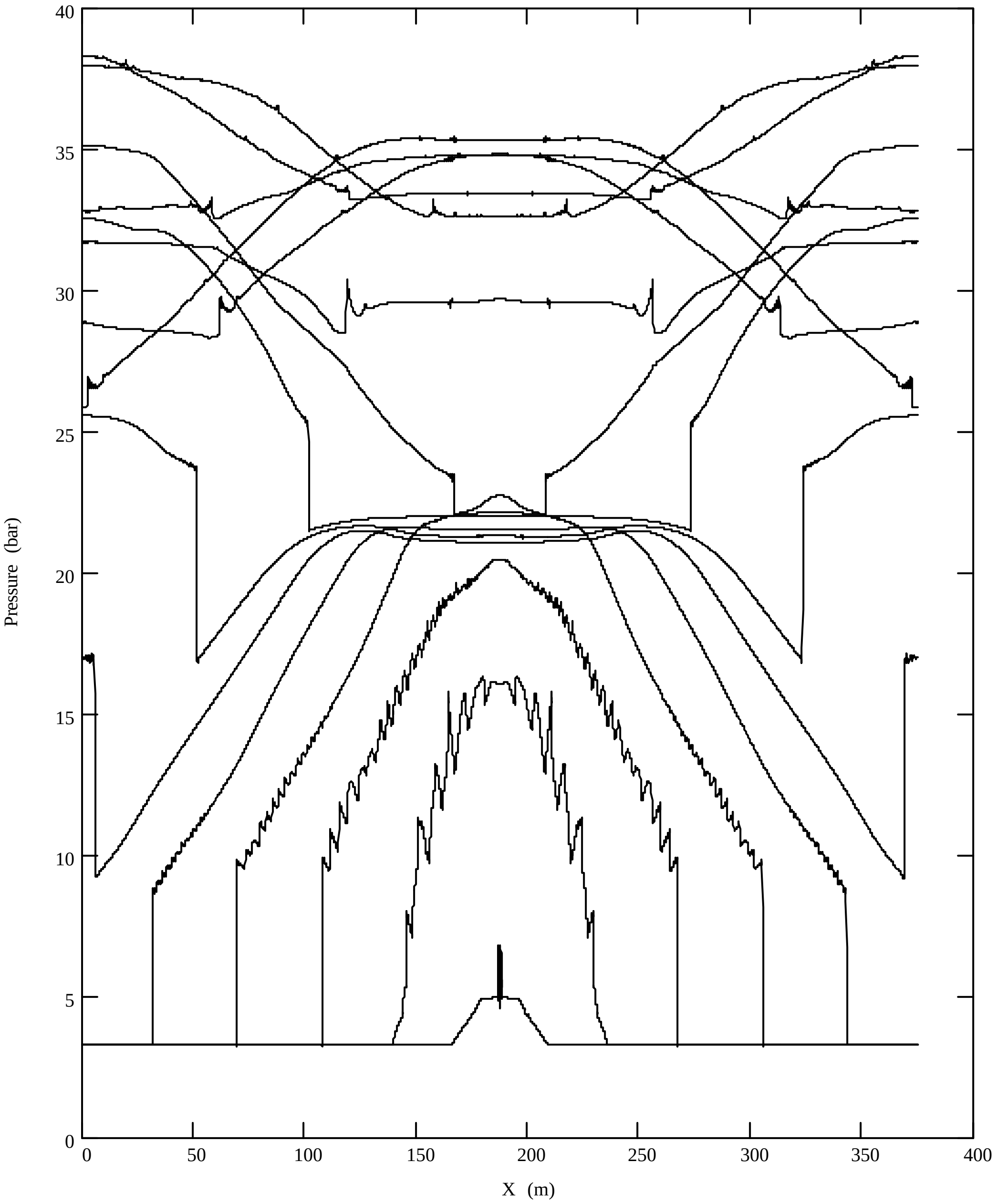
Evolution of the cable temperature. Times: 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.3, 2.5, 2.7, 2.9 s.



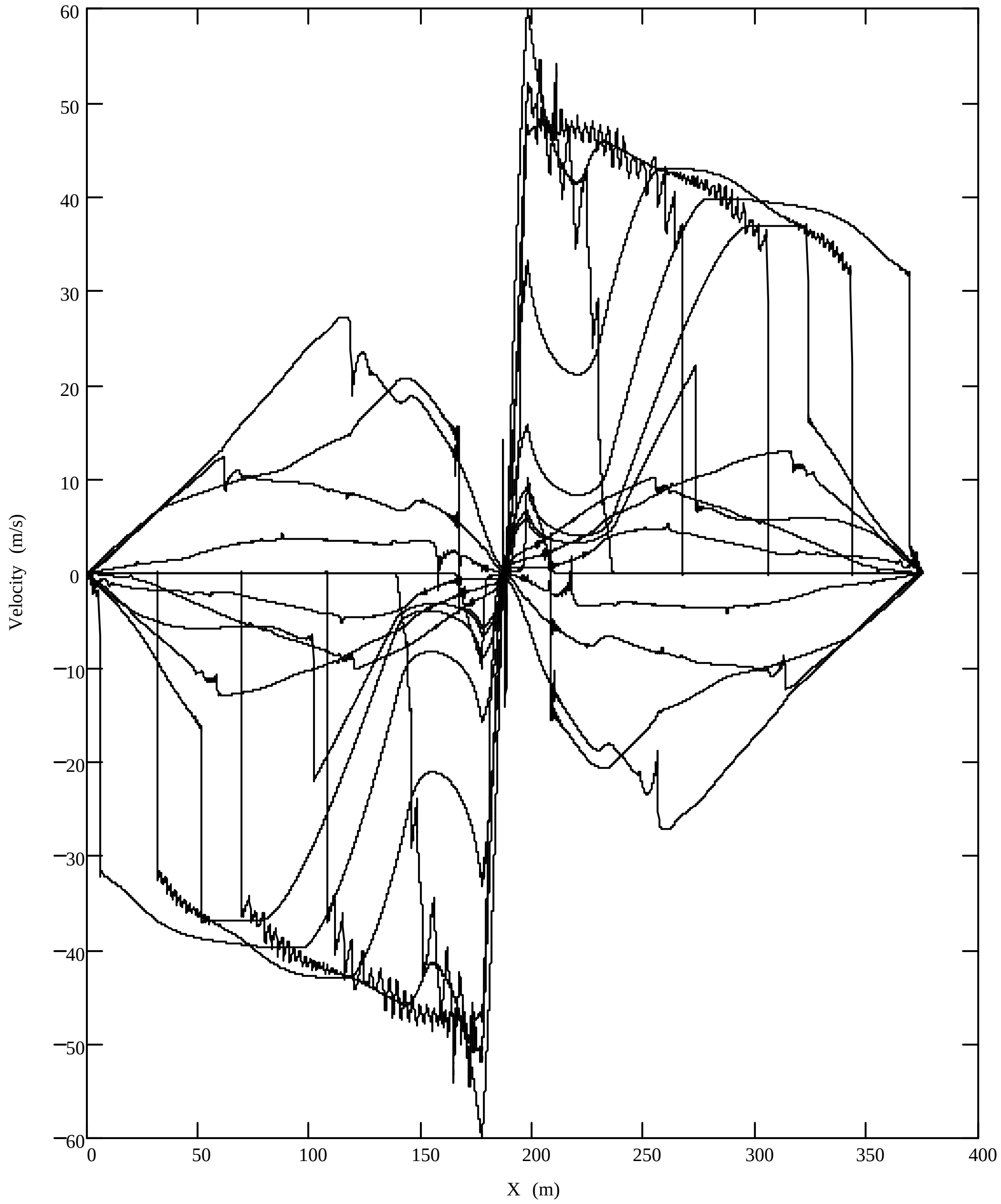
Evolution of the He temperature. Times: 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.3, 2.5, 2.7, 2.9 s.



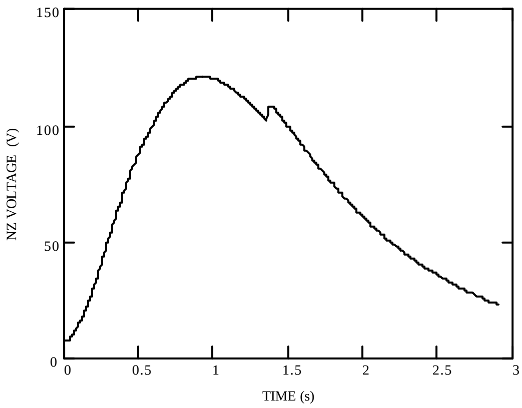
Evolution of the He density. Times: 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.3, 2.5, 2.7, 2.9 s.

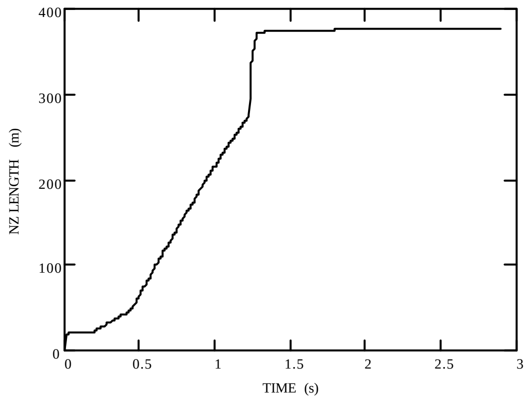


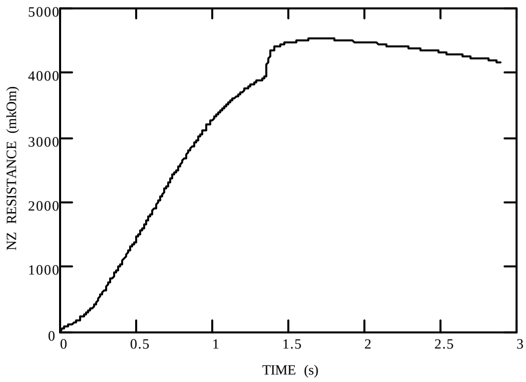
Evolution of the He pressure. Times: 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.3, 2.5, 2.7, 2.9 s.

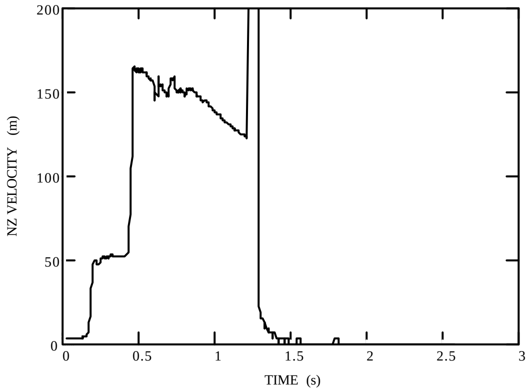


Evolution of the He velocity. Times: 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.3, 2.5, 2.7, 2.9 s.

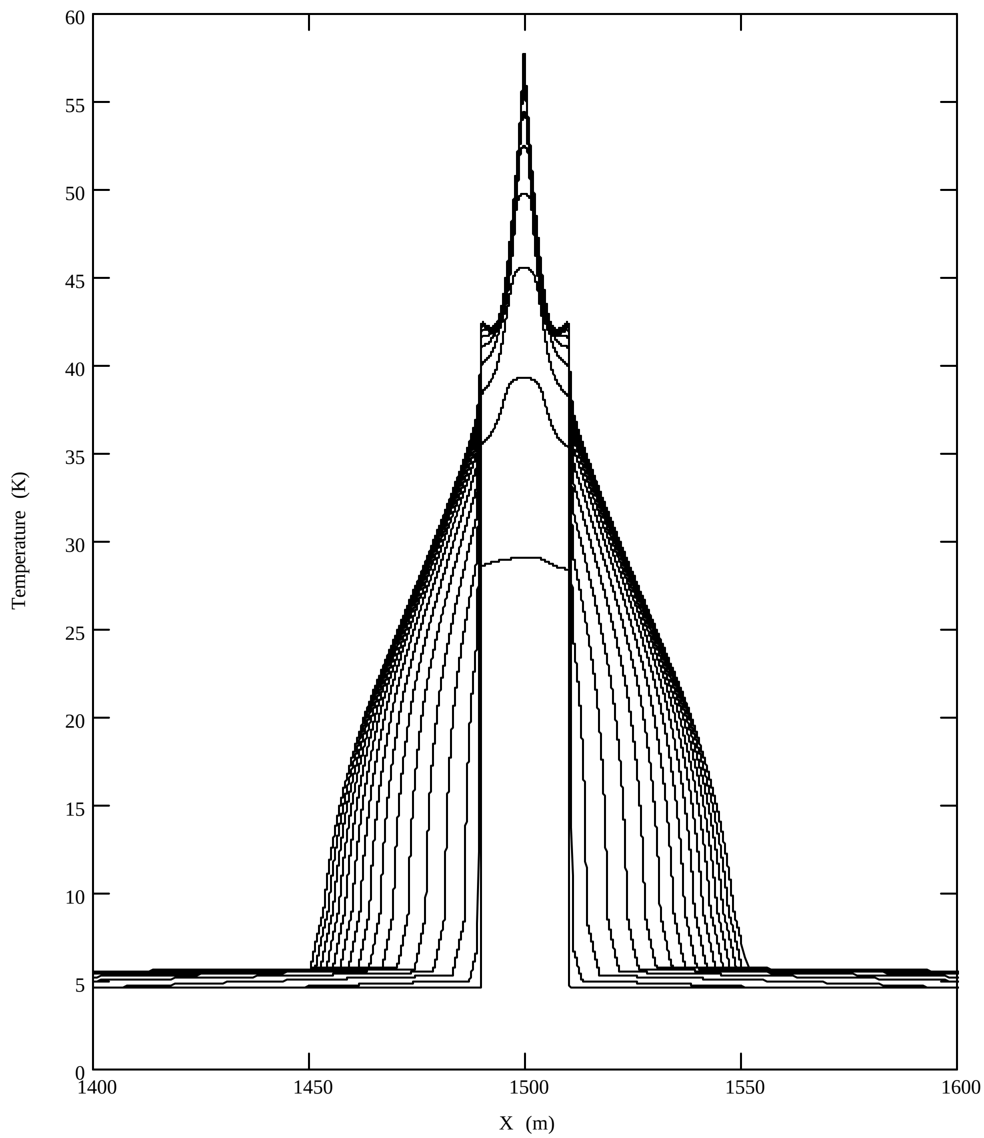

NZ VOLTAGE (V)
TIME (s)
0
50
100
150
0.5
1
1.5
2
2.5
3


NZ LENGTH (m)
TIME (s)
0
100
200
300
400
0.5
1
1.5
2
2.5
3

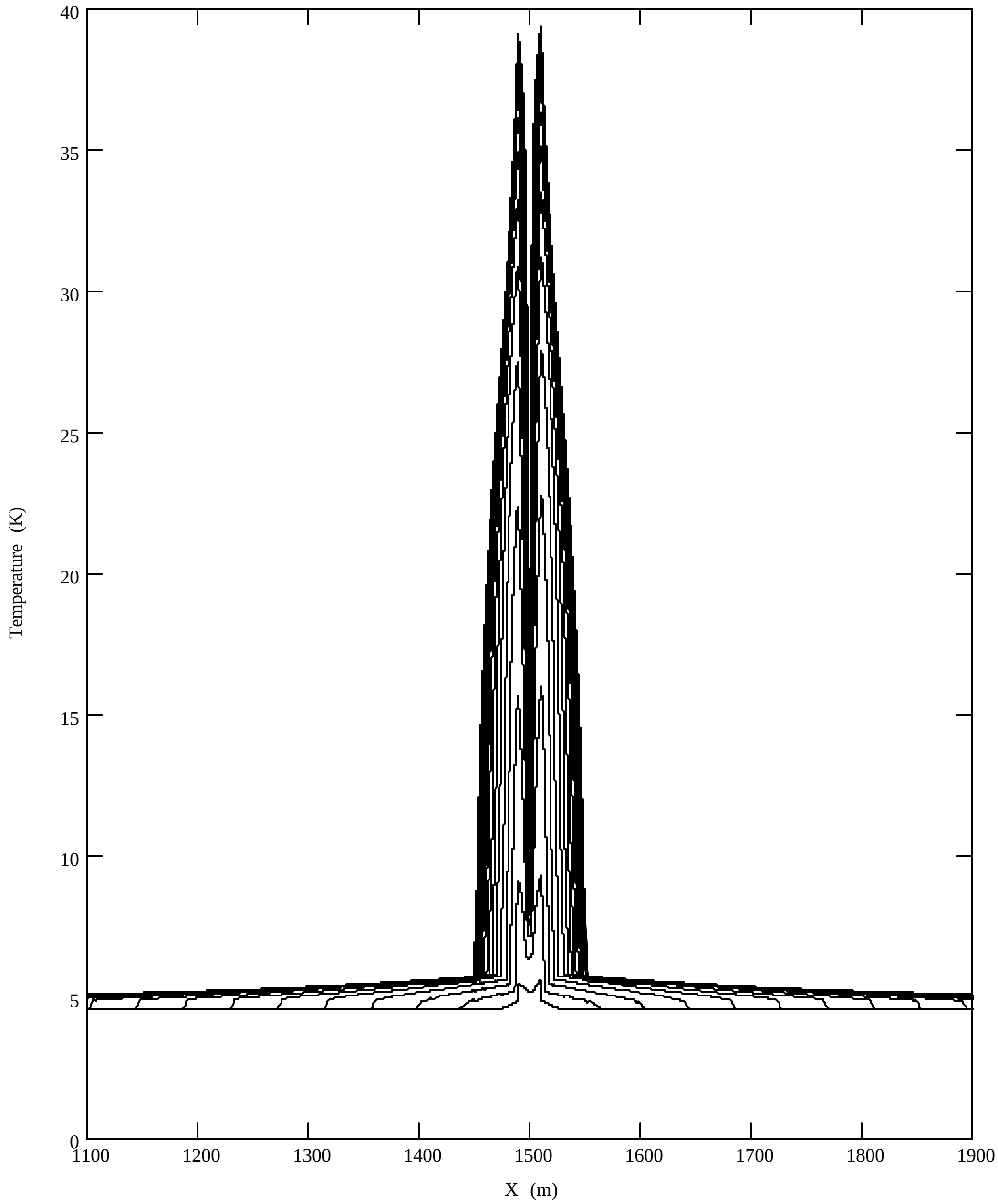

NZ RESISTANCE (mkOm)
TIME (s)
0
1000
2000
3000
4000
5000
0.5
1
1.5
2
2.5
3


NZ VELOCITY (m)
TIME (s)
0
50
100
150
200
0.5
1
1.5
2
2.5
3

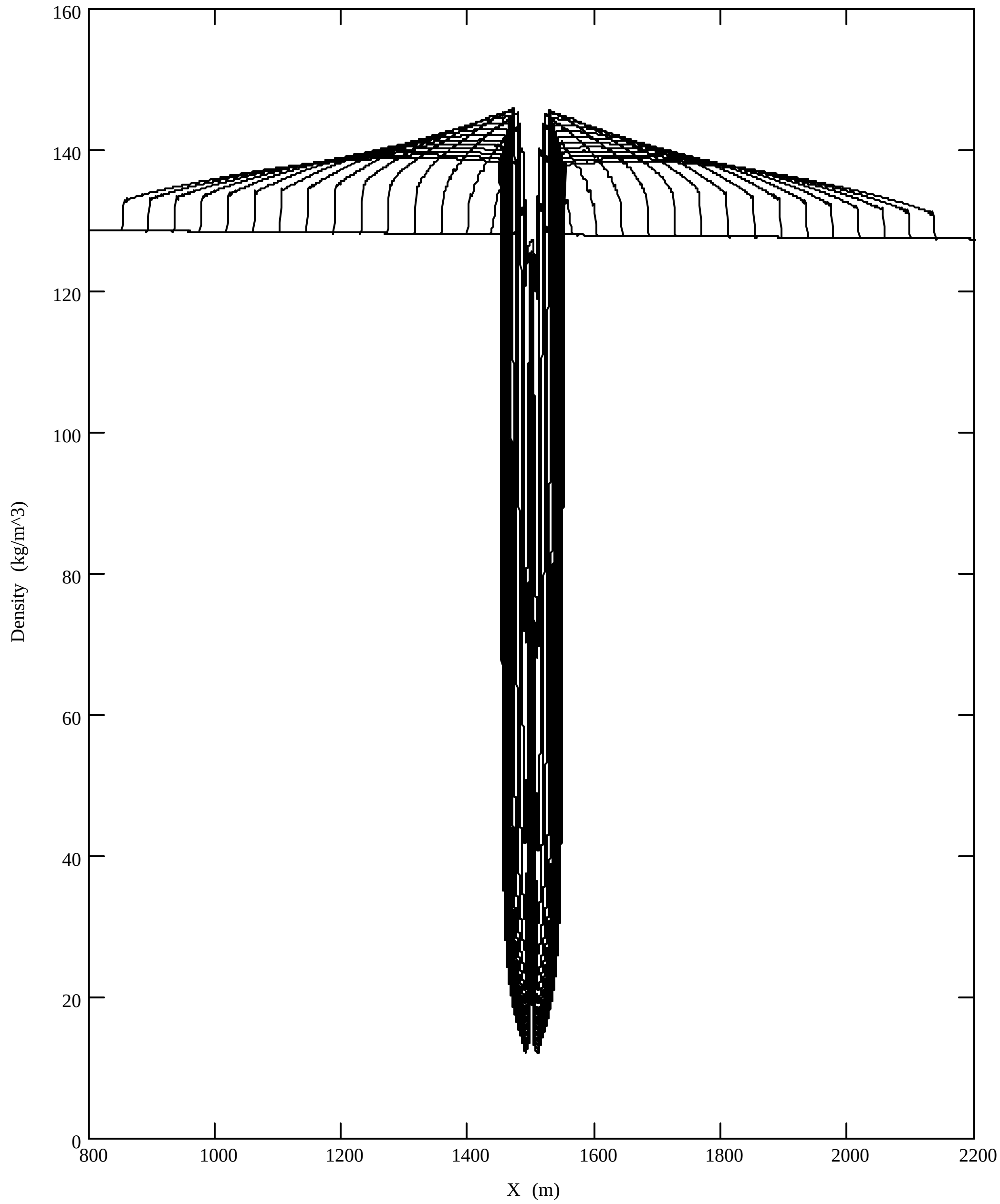
Option 5: L=3000 m, $l_{disturbance}$=20 m (located in the center of conductor with two layers of Rutherford cable). Current carrier copper is enlarged about twice.
Initial conditions: P_{in}=3.3 bar, T_{in}=4.6 K, dm / dt=40 g / s, Q_{ext}=0 W / m
Conductor model: conductor is divided into three parts: 1451+100+1451 m. Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 2 cm (other ones use 1m space step and utilize 1D approach for tubes)



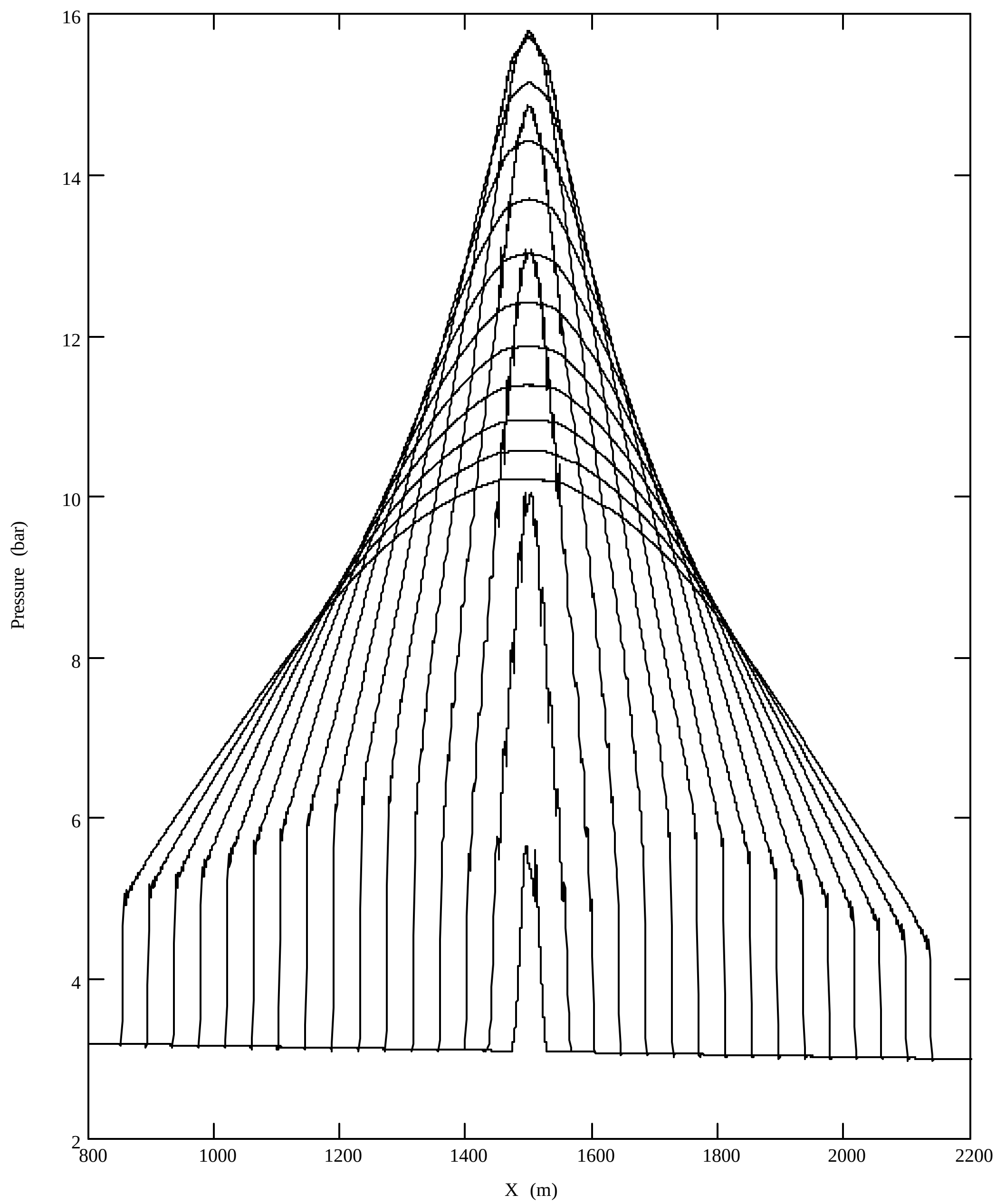
Evolution of the cable temperature. Times: 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.3, 2.5, 2.7, 2.9, 3.1 s.



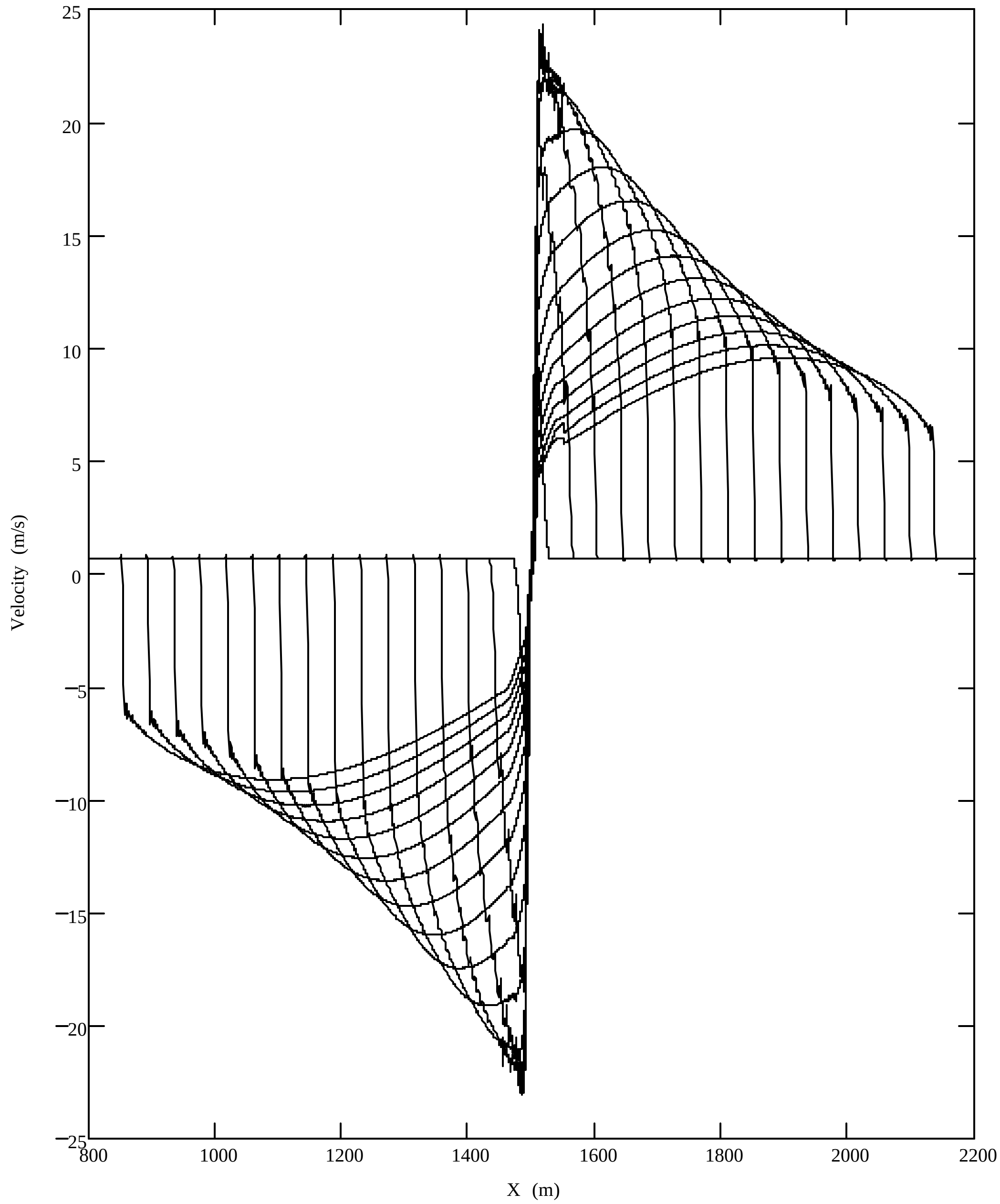
Evolution of the He temperature. Times: 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.3, 2.5, 2.7, 2.9, 3.1 s.



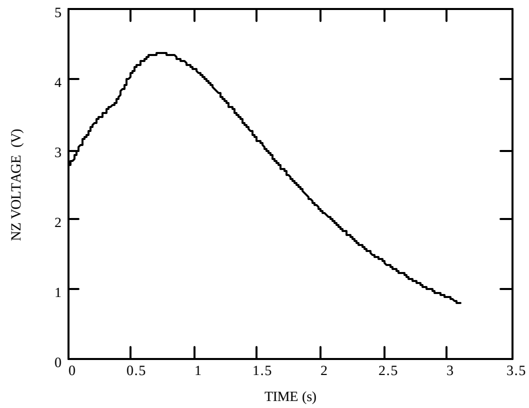
Evolution of the He density. Times: 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.3, 2.5, 2.7, 2.9, 3.1 s.

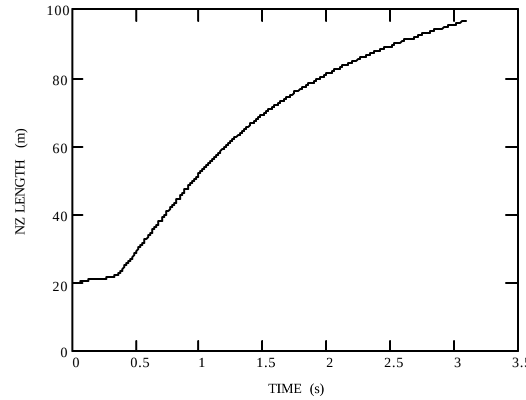


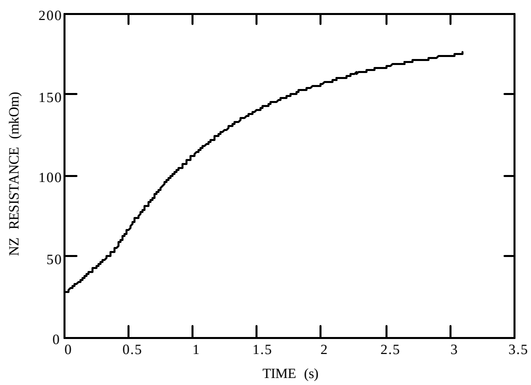
Evolution of the He pressure. Times: 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.3, 2.5, 2.7, 2.9, 3.1 s.

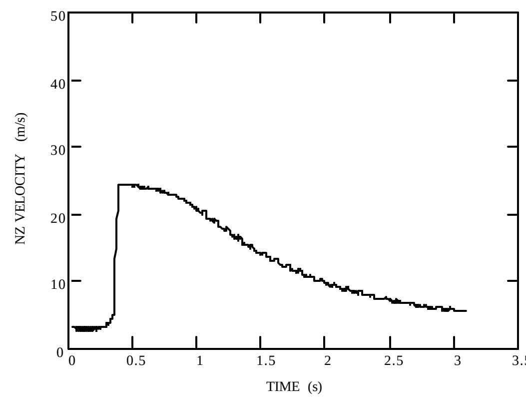


Evolution of the He velocity. Times: 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.3, 2.5, 2.7, 2.9, 3.1 s.

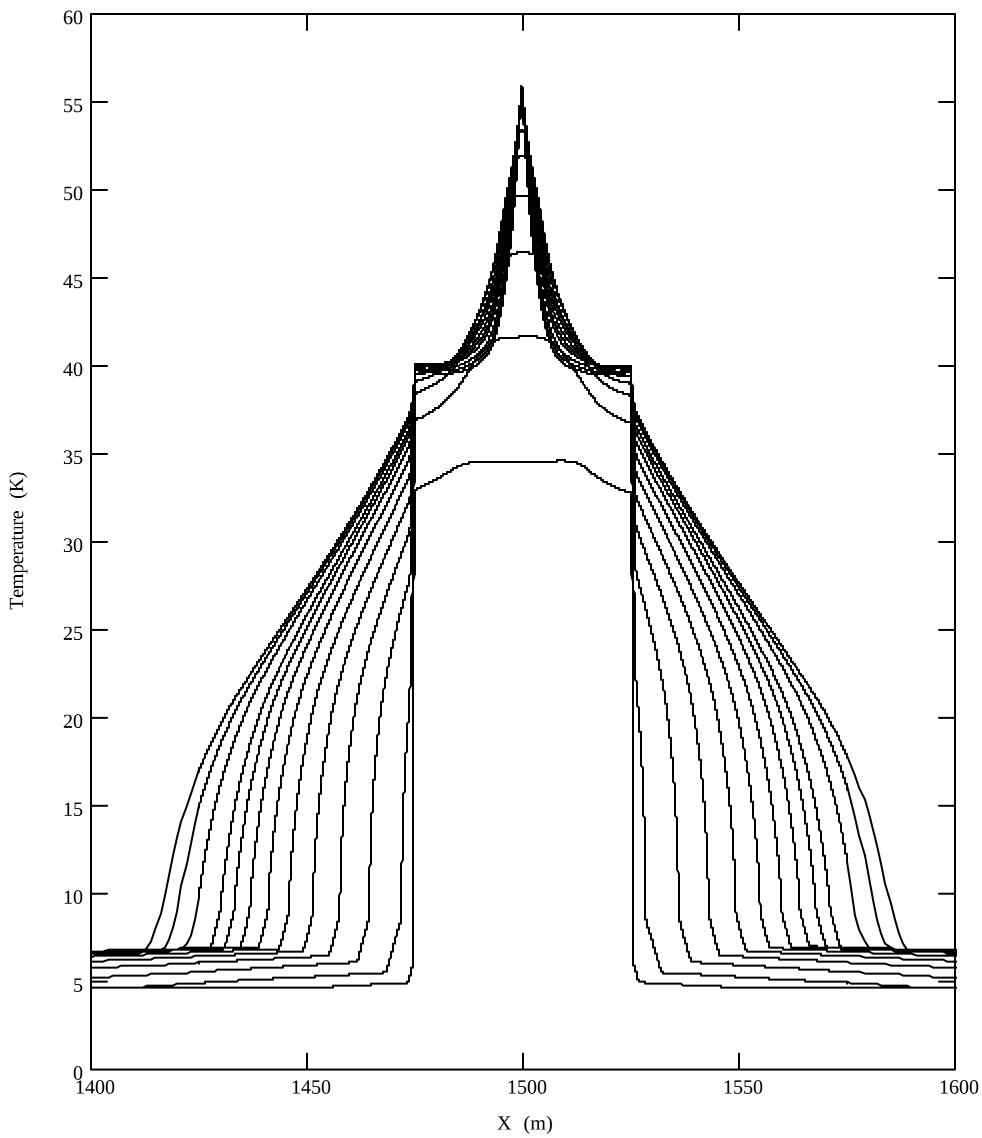

NZ VOLTAGE (V)
TIME (s)


NZ LENGTH (m)
TIME (s)

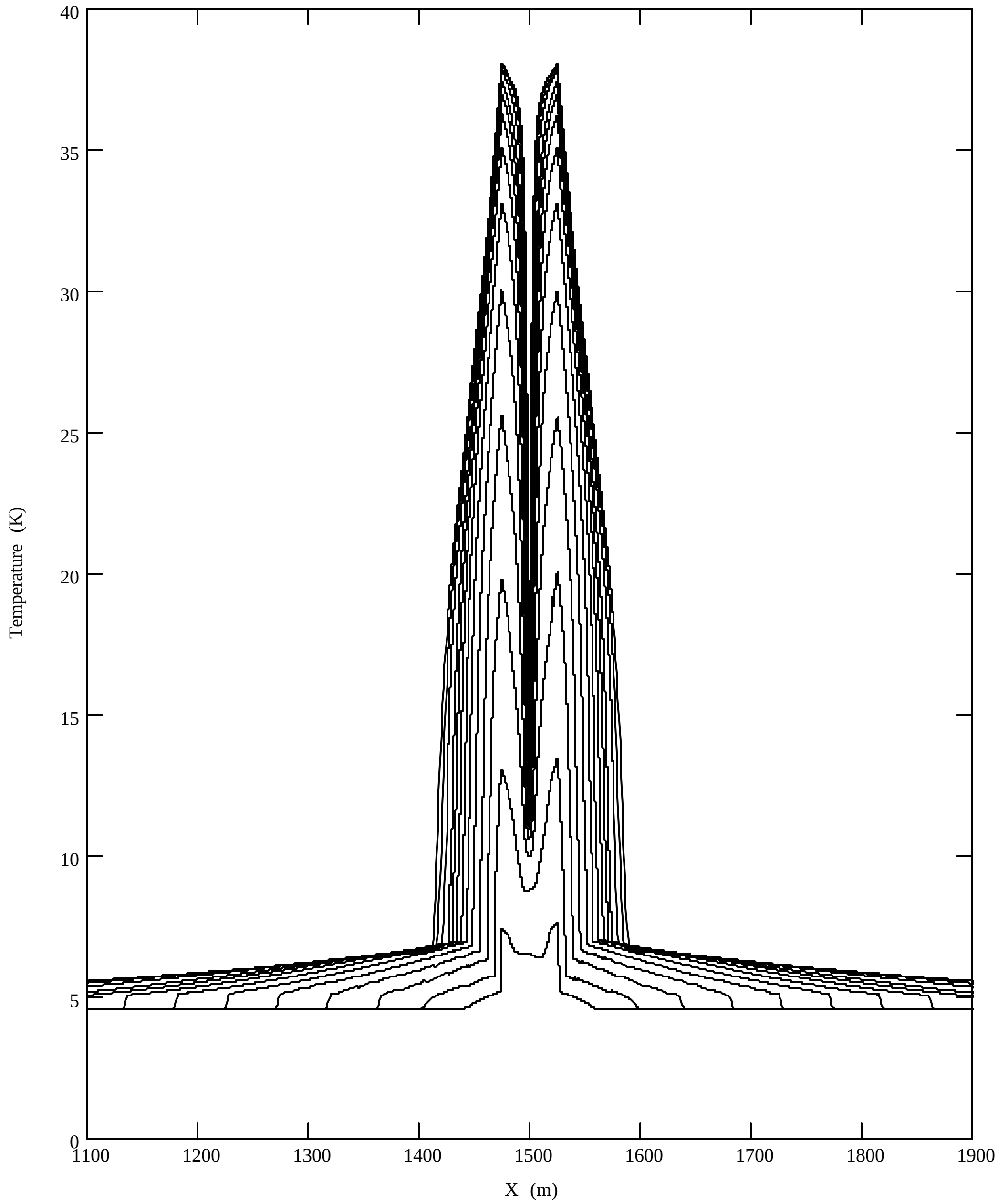

NZ RESISTANCE (mkOm)
TIME (s)


NZ VELOCITY (m/s)
TIME (s)

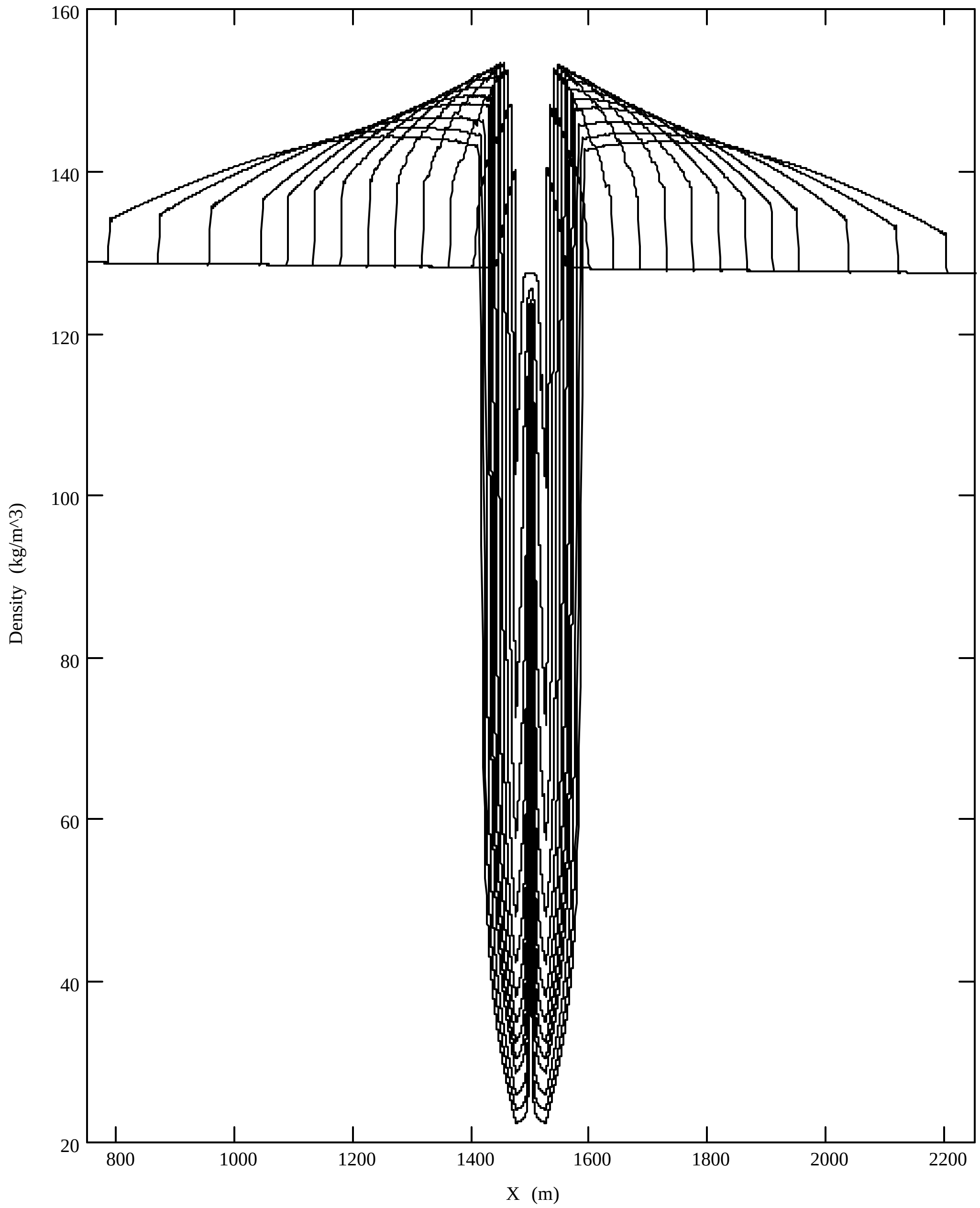
Option 5a: L=3000 m, $l_{disturbance}$=50 m (located in the center of conductor with two layers of Rutherford cable). Current carrier copper is enlarged about twice.
Initial conditions: P_{in}=3.3 bar, T_{in}=4.6 K, dm / dt=40 g / s, Q_{ext}=0 W / m
Conductor model: conductor is divided into three parts: 1425+150+1425 m. Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 2 cm (other ones use 1m space step and utilize 1D approach for tubes)



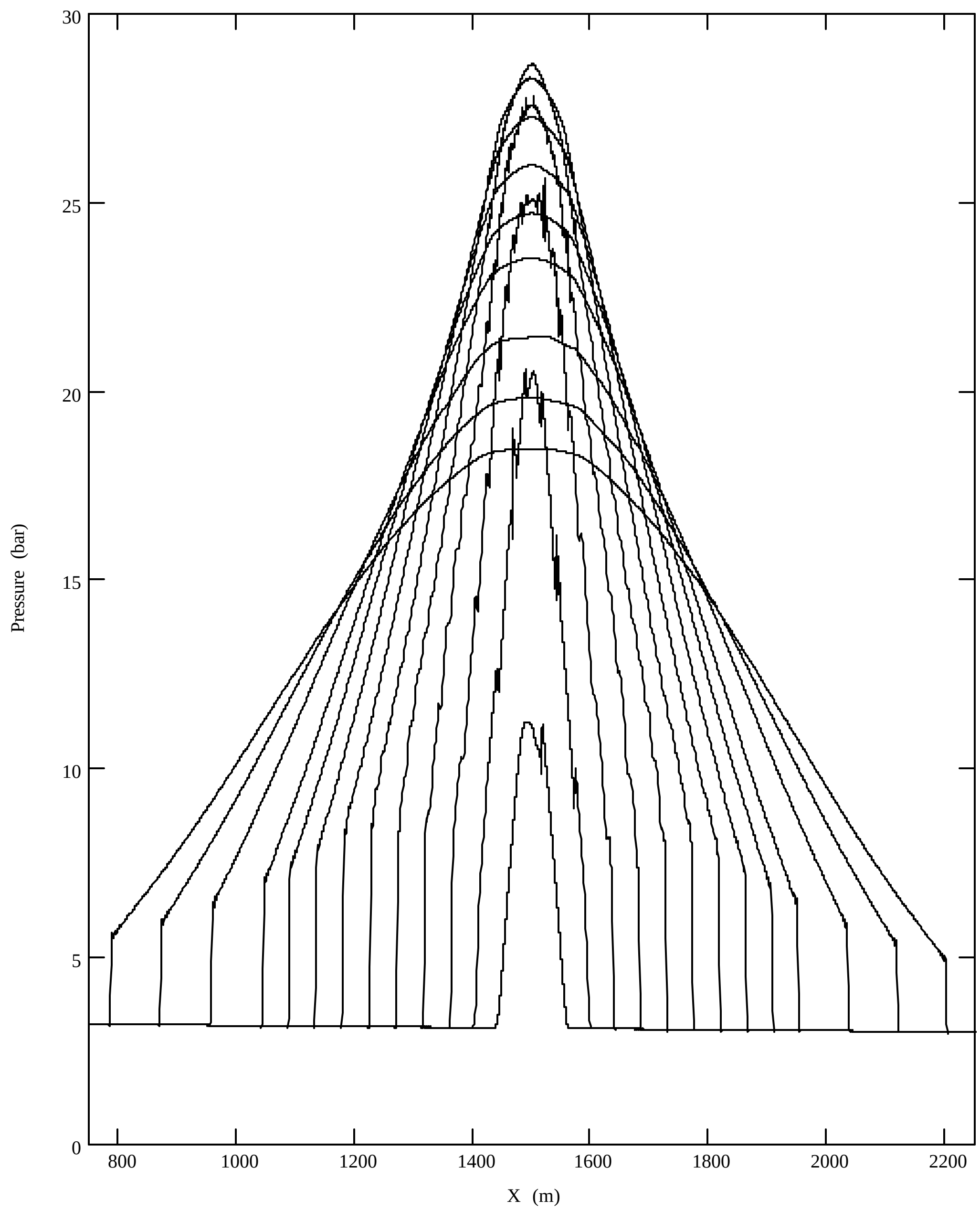
Evolution of the cable temperature. Times: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.4, 2.8, 3.2 s.



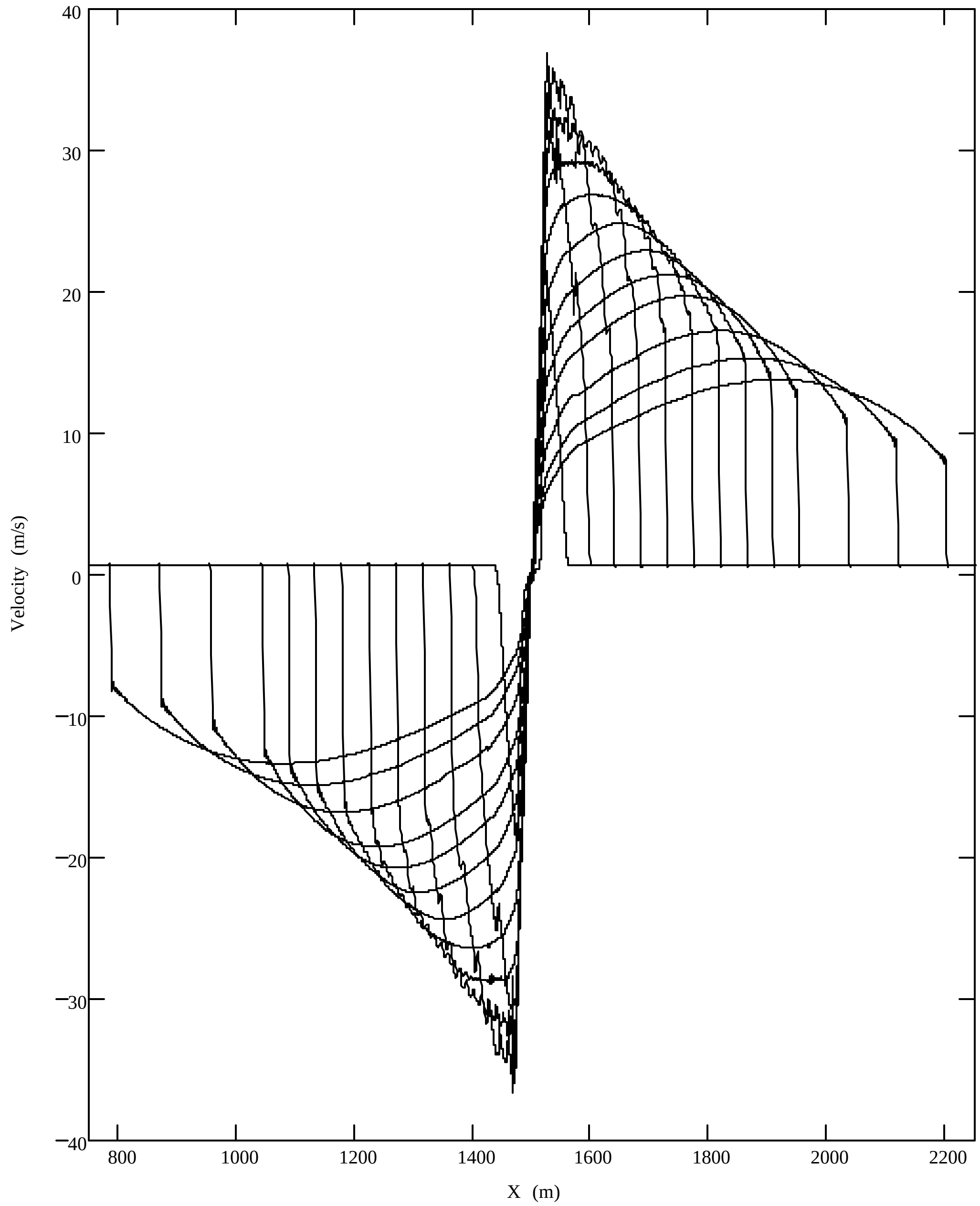
Evolution of the He temperature. Times: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.4, 2.8, 3.2 s.



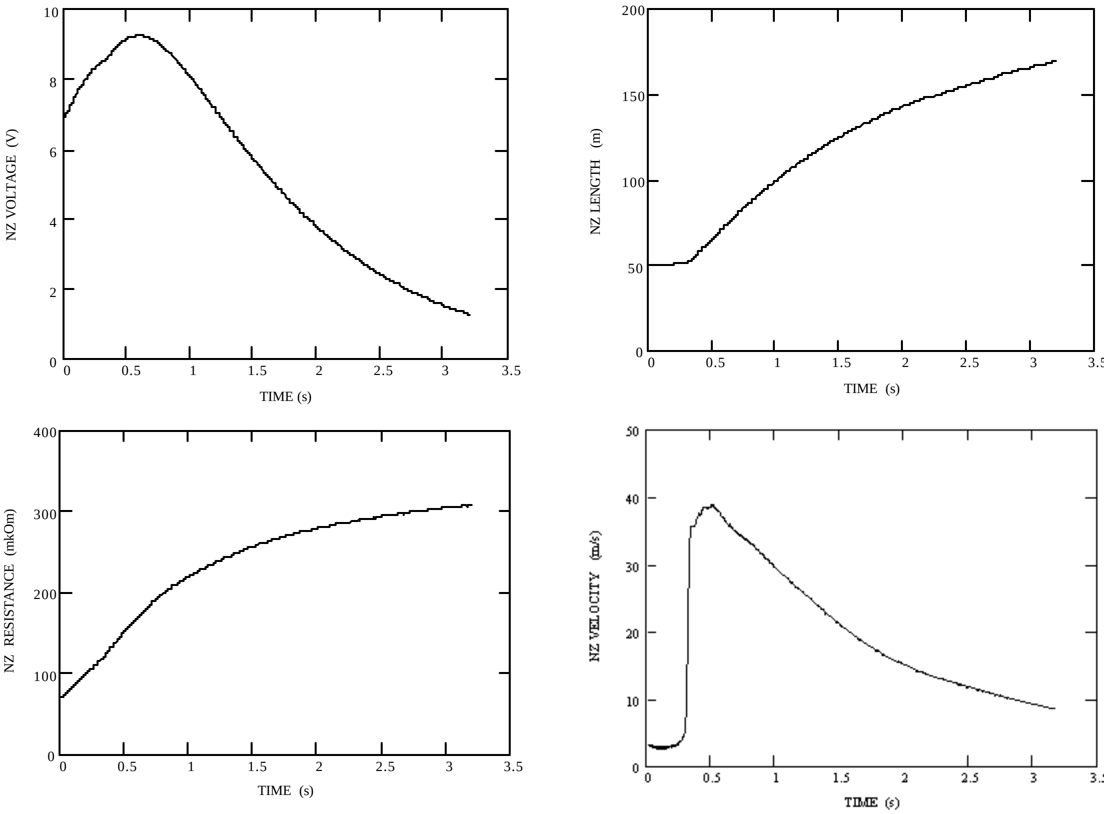
Evolution of the He density. Times: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.4, 2.8, 3.2 s.



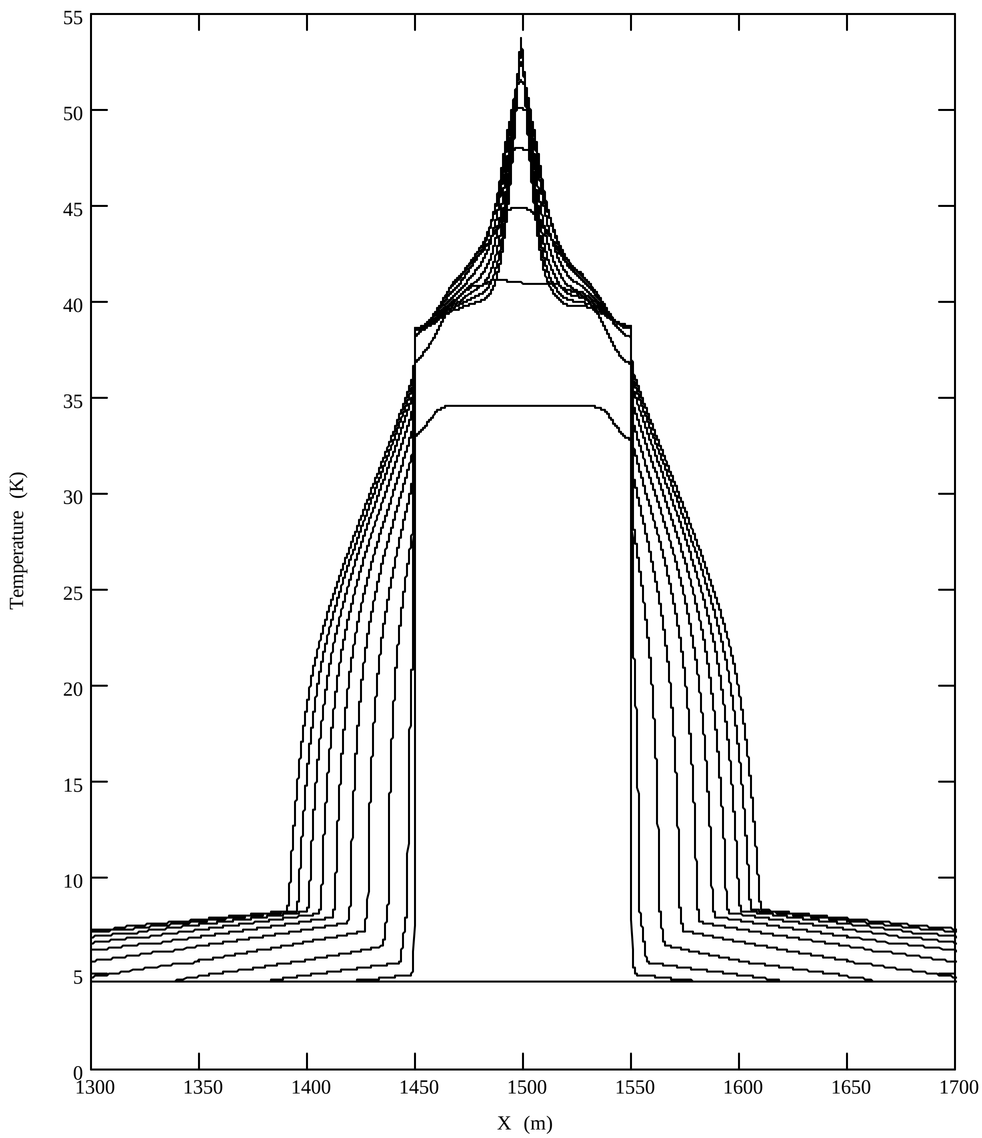
Evolution of the He pressure. Times: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.4, 2.8, 3.2 s.



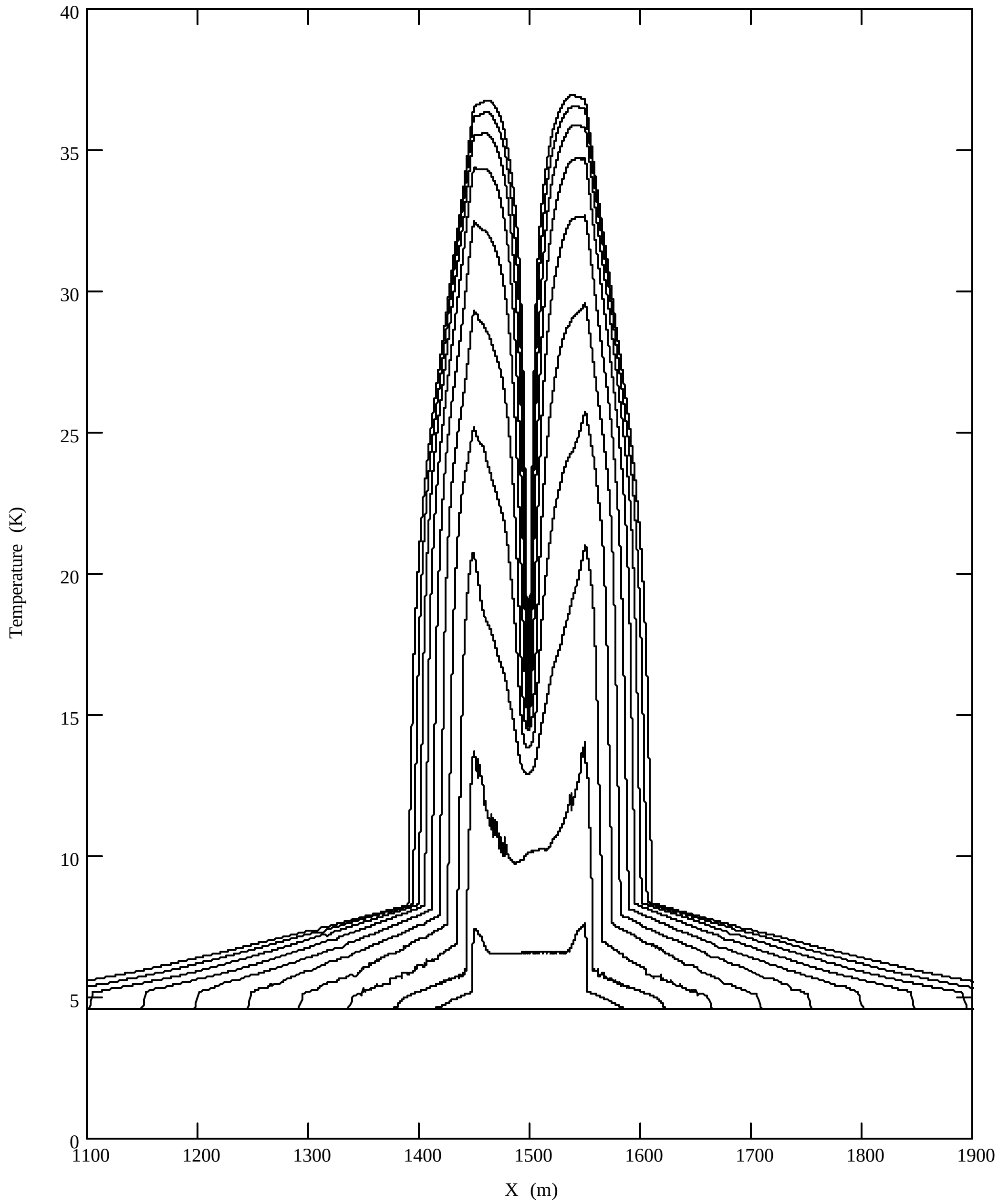
Evolution of the He velocity. Times: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.4, 2.8, 3.2 s.


NZ VOLTAGE (V)
TIME (s)
NZ LENGTH (m)
TIME (s)
NZ RESISTANCE (mkOm)
TIME (s)
NZ VELOCITY (m/s)
TIME (s)

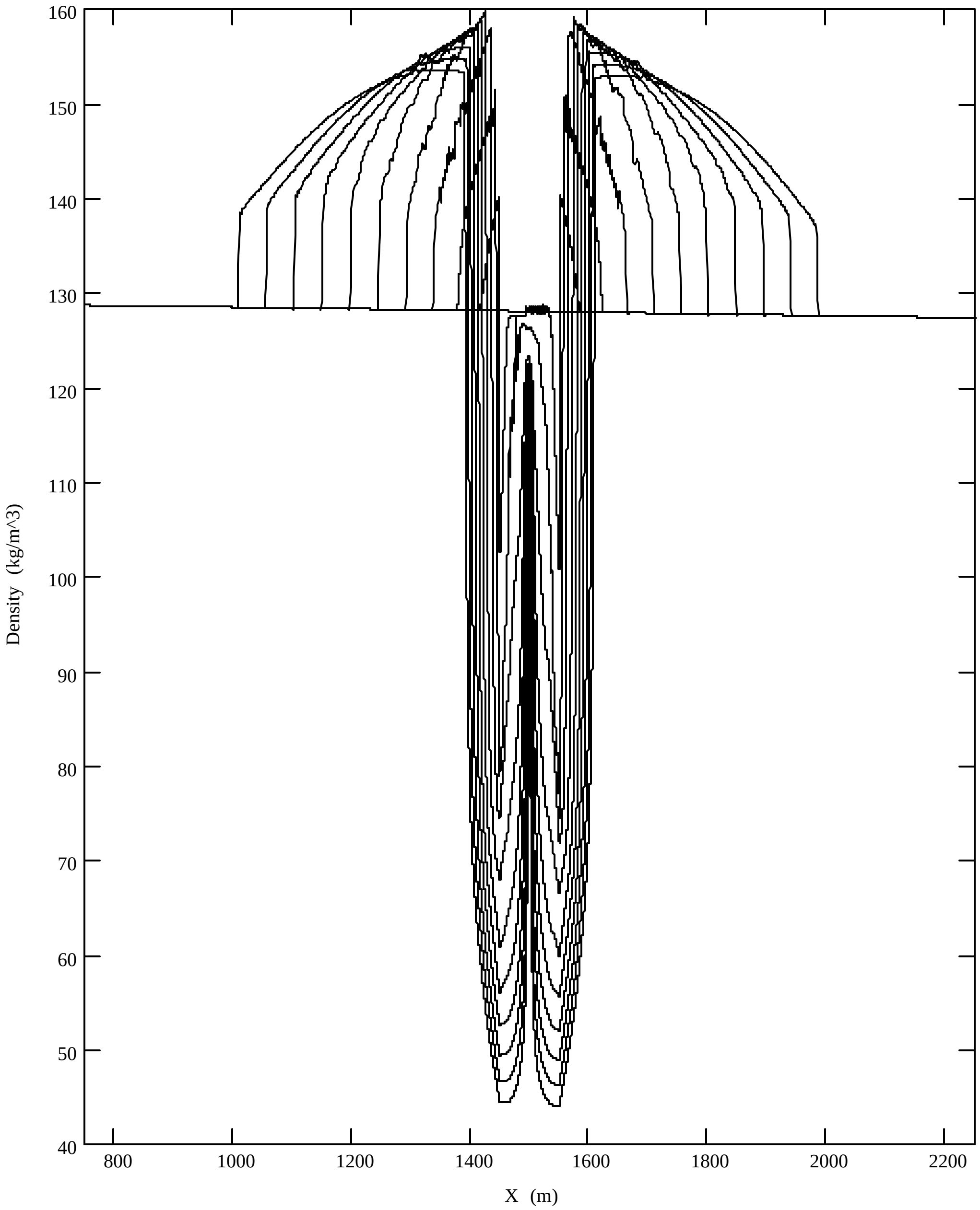
Option 5b: L=3000 m, $l_{disturbance}$=100 m (located in the center of conductor with two layers of Rutherford cable). Current carrier copper is enlarged about twice.
Initial conditions: P_{in}=3.3 bar, T_{in}=4.6 K, dm / dt=40 g / s, Q_{ext}=0 W / m
Conductor model: conductor is divided into three parts: 1375+300+1375 m. Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 4 cm (other ones use 1m space step and utilize 1D approach for tubes)



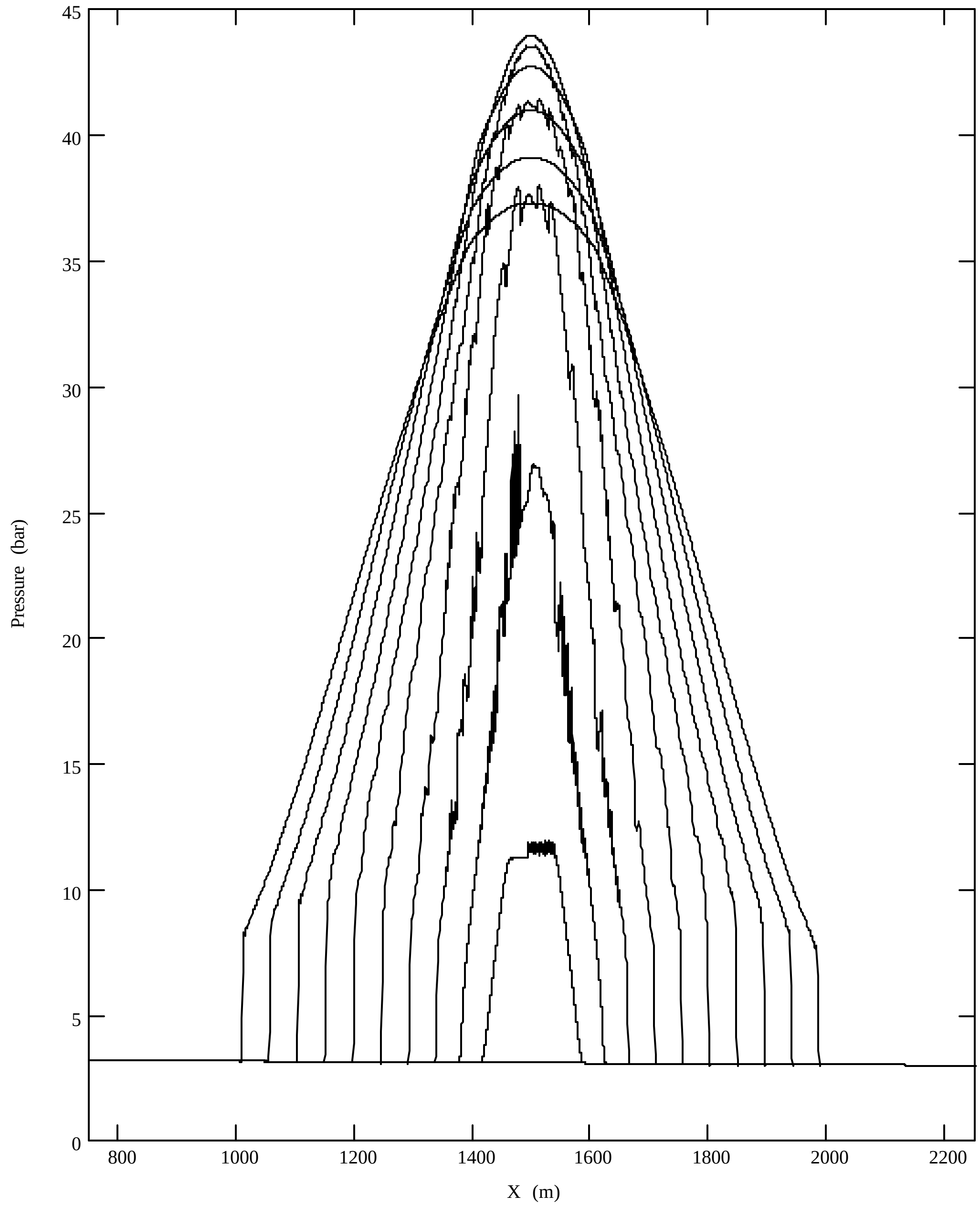
Evolution of the cable temperature. Times: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0 s.



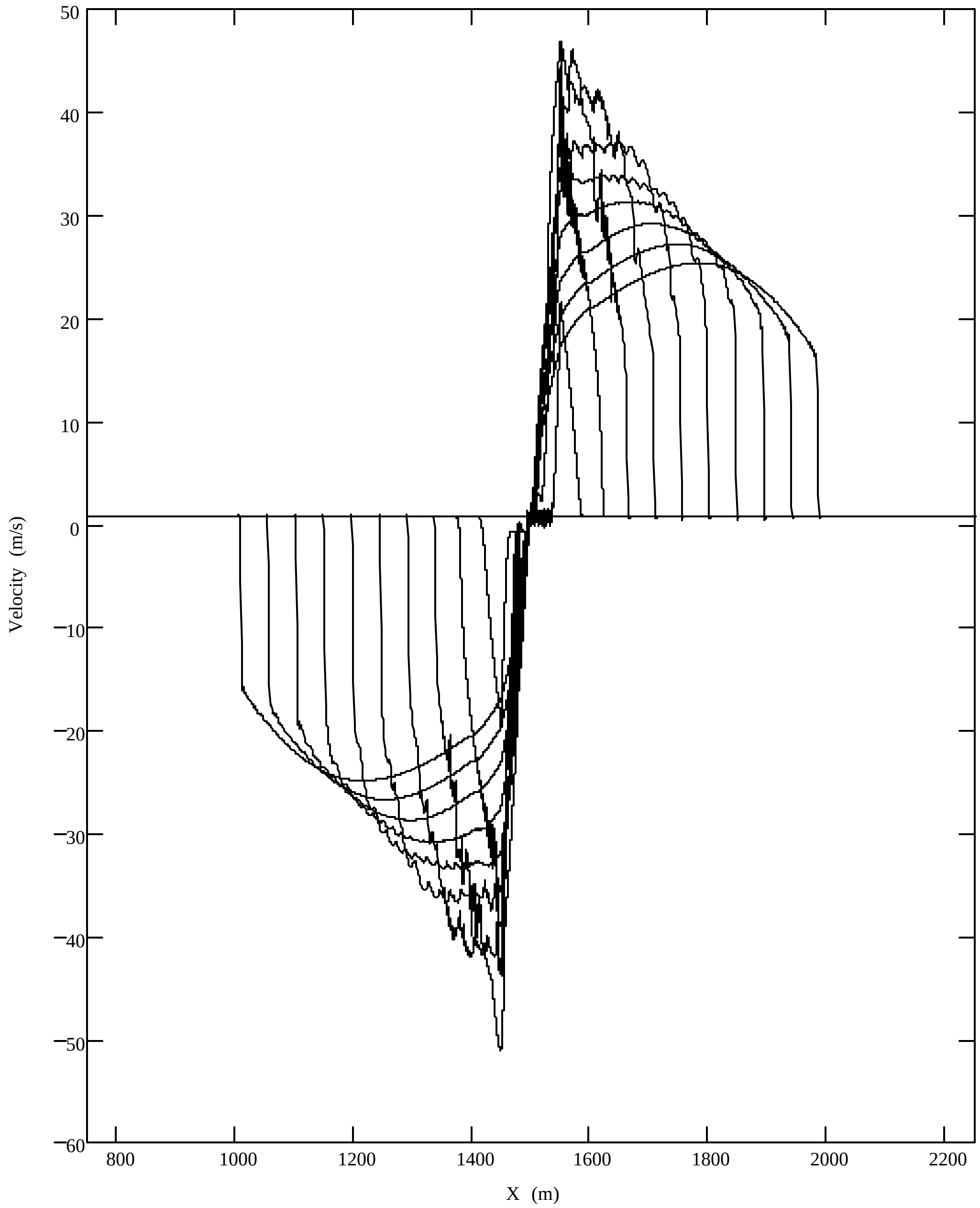
Evolution of the He temperature. Times: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0s.



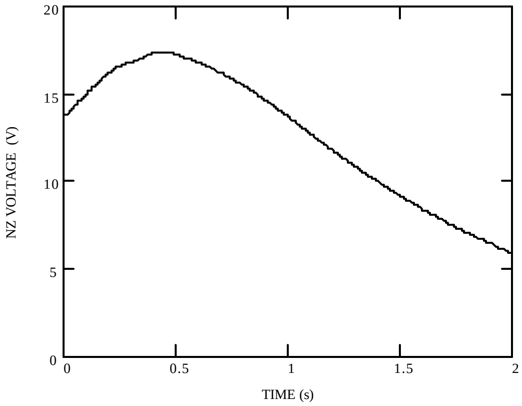
Evolution of the He density. Times: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0 s.

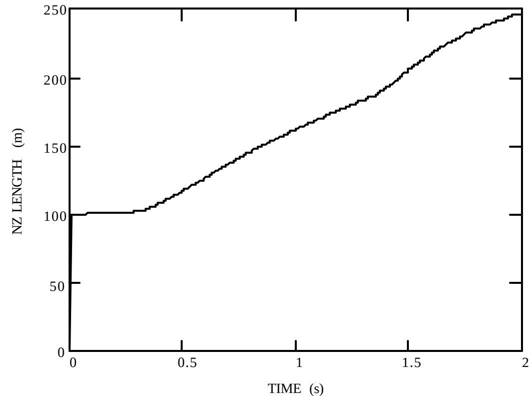


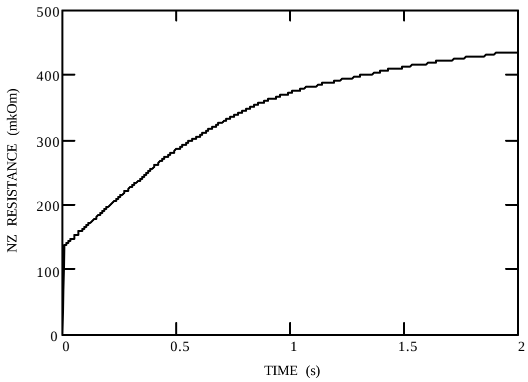
Evolution of the He pressure. Times: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0 s.

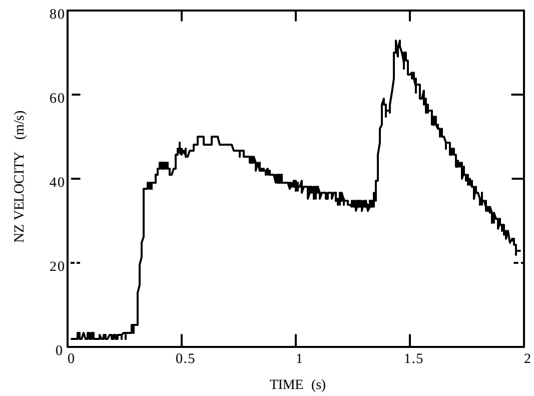


Evolution of the He velocity. Times: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0 s.

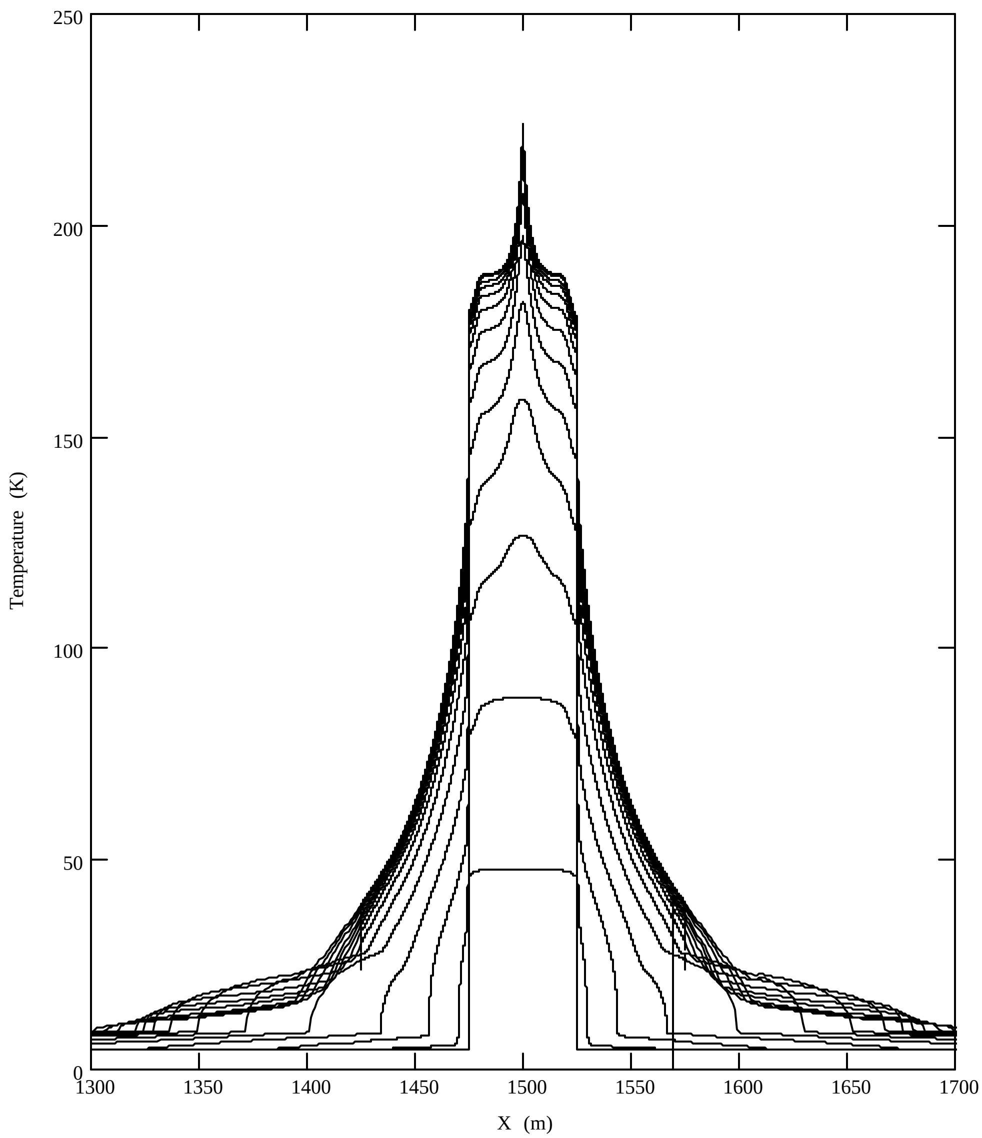

NZ VOLTAGE (V)
TIME (s)
0
5
10
15
20
0
0.5
1
1.5
2


NZ LENGTH (m)
TIME (s)
0
50
100
150
200
250
0
0.5
1
1.5
2

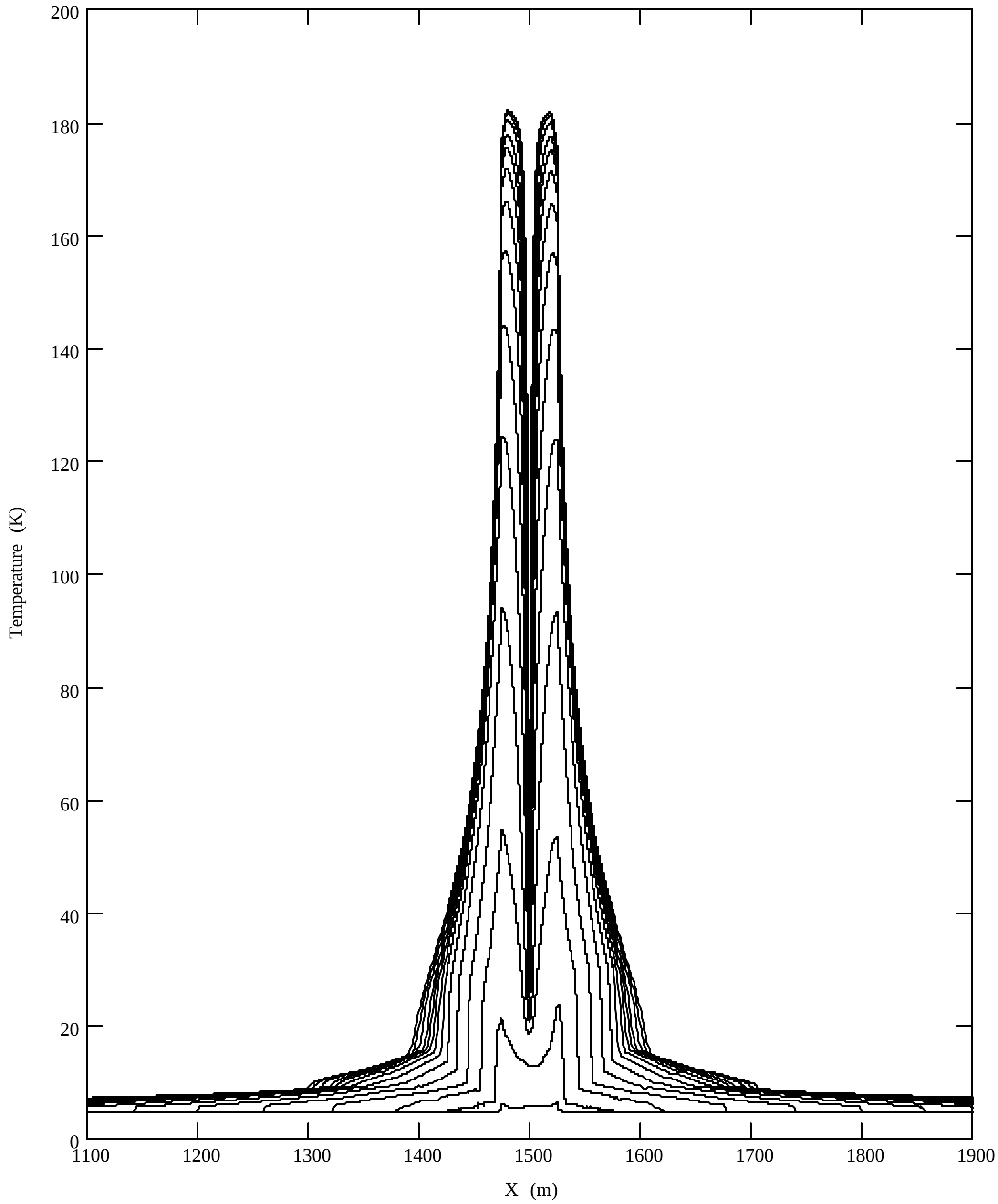

NZ RESISTANCE (mkOm)
TIME (s)
0
100
200
300
400
500
0
0.5
1
1.5
2


NZ VELOCITY (m/s)
TIME (s)
0
20
40
60
80
0
0.5
1
1.5
2

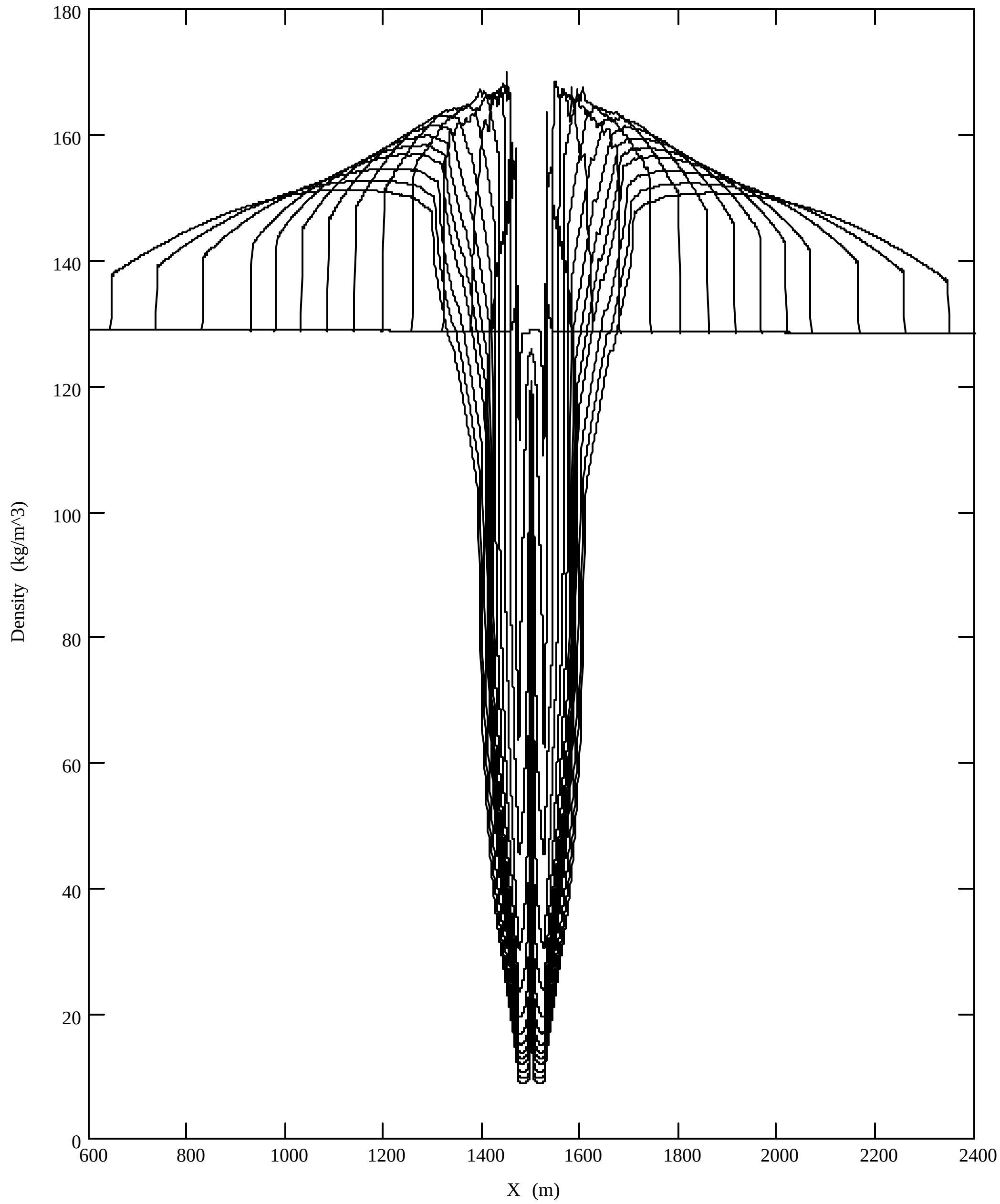
Option 6: L=3000 m, $l_{disturbance}$=50 m (located in the center of conductor with two layers of Rutherford cable)
Initial conditions: P_{in}=3.3 bar, T_{in}=4.6 K, dm / dt=40 g / s, Q_{ext}=0 W / m
Conductor model: conductor is divided into three parts: 1425+150+1425 m. Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 2 cm (other ones use 1m space step and utilize 1D approach for tubes)



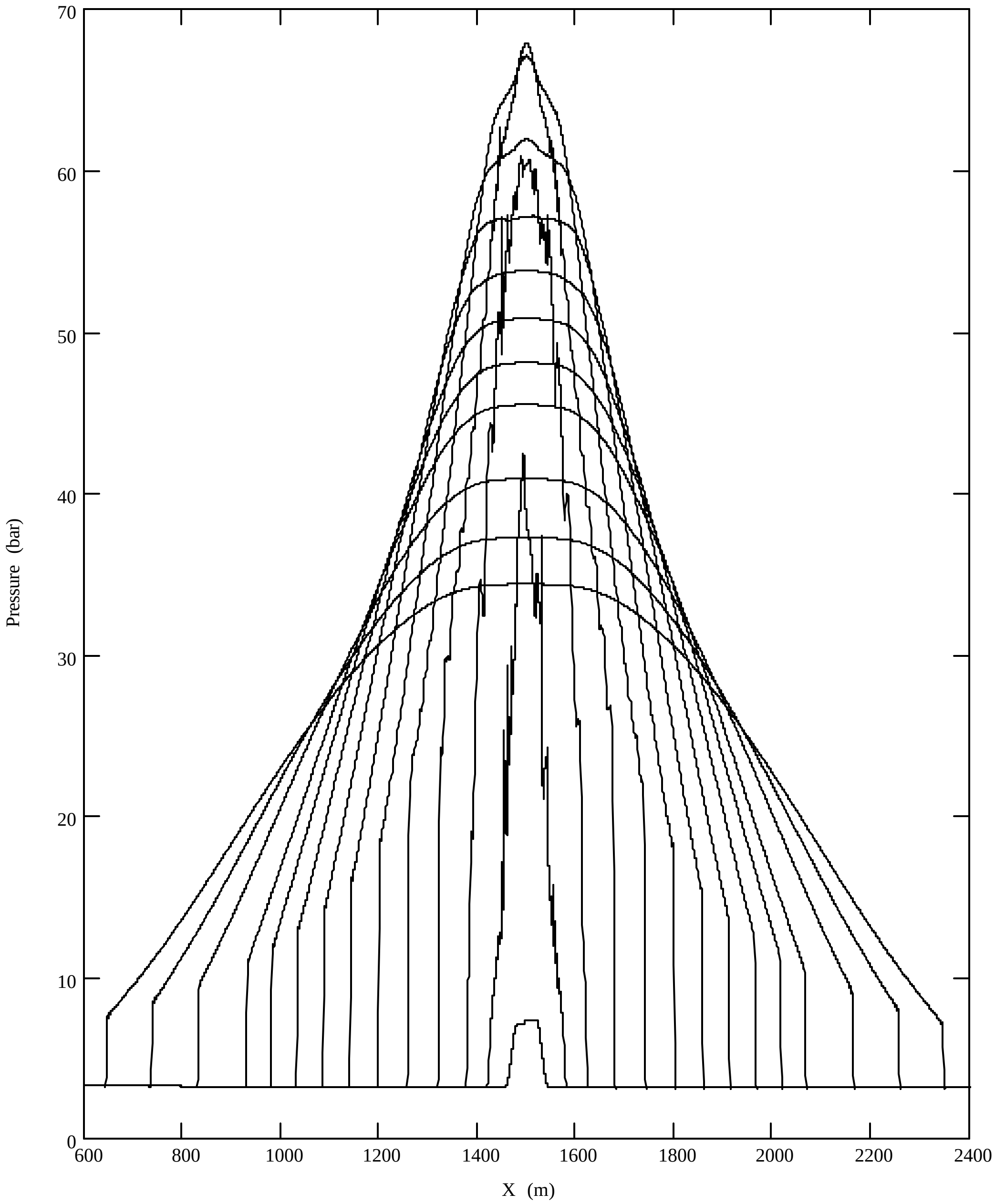
Evolution of the cable temperature. Times: 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.5, 2.9, 3.3 s.



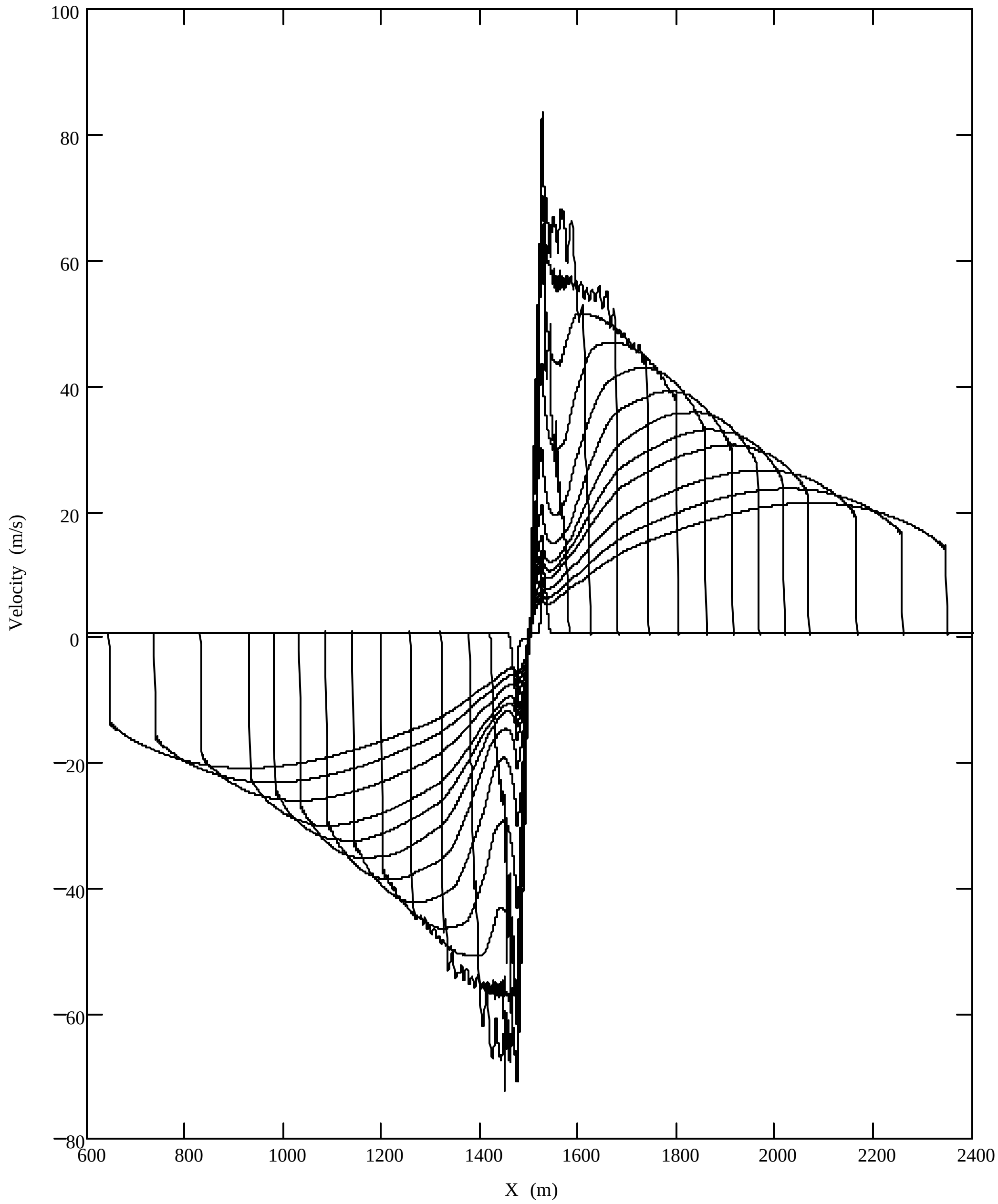
Evolution of the He temperature. Times: 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.5, 2.9, 3.3 s.



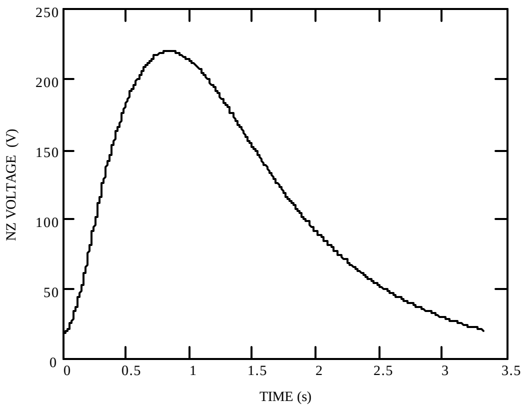
Evolution of the He density. Times: 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.5, 2.9, 3.3 s.



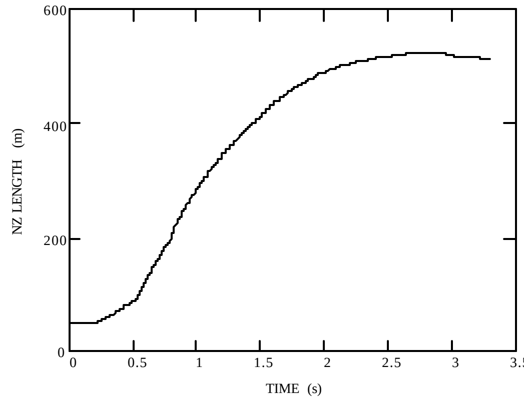
Evolution of the He pressure. Times: 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.5, 2.9, 3.3 s.



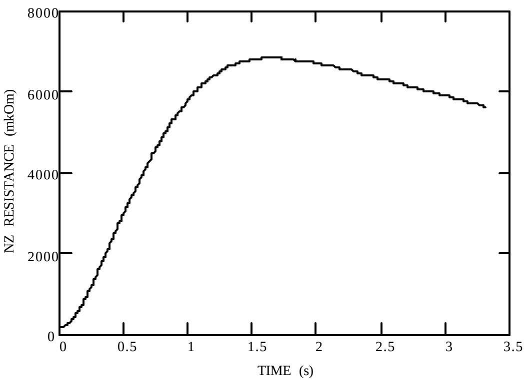
Evolution of the He velocity. Times: 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7, 1.9, 2.1, 2.5, 2.9, 3.3 s.



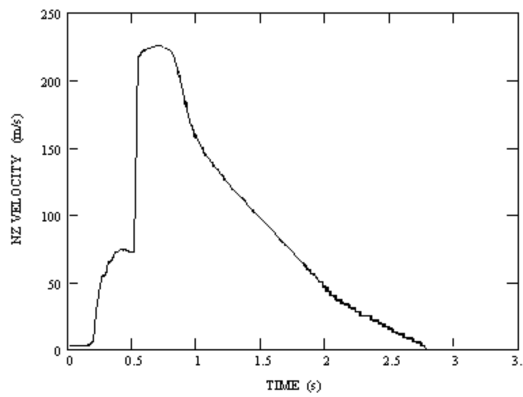
NZ VOLTAGE (V)
0
50
100
150
200
250
TIME (s)
0
0.5
1
1.5
2
2.5
3
3.5



NZ LENGTH (m)
0
200
400
600
TIME (s)
0
0.5
1
1.5
2
2.5
3
3.5

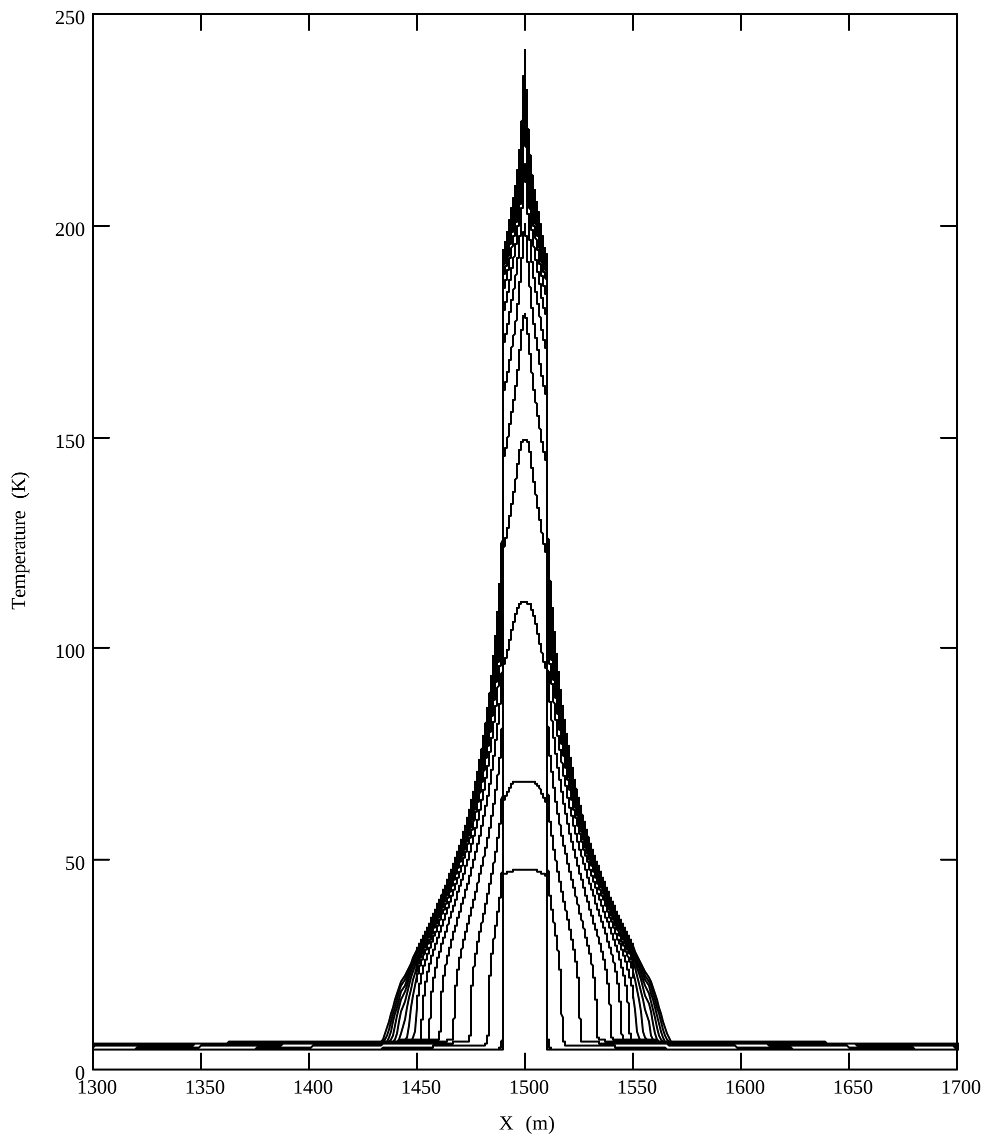


NZ RESISTANCE (mkOm)
0
2000
4000
6000
8000
TIME (s)
0
0.5
1
1.5
2
2.5
3
3.5

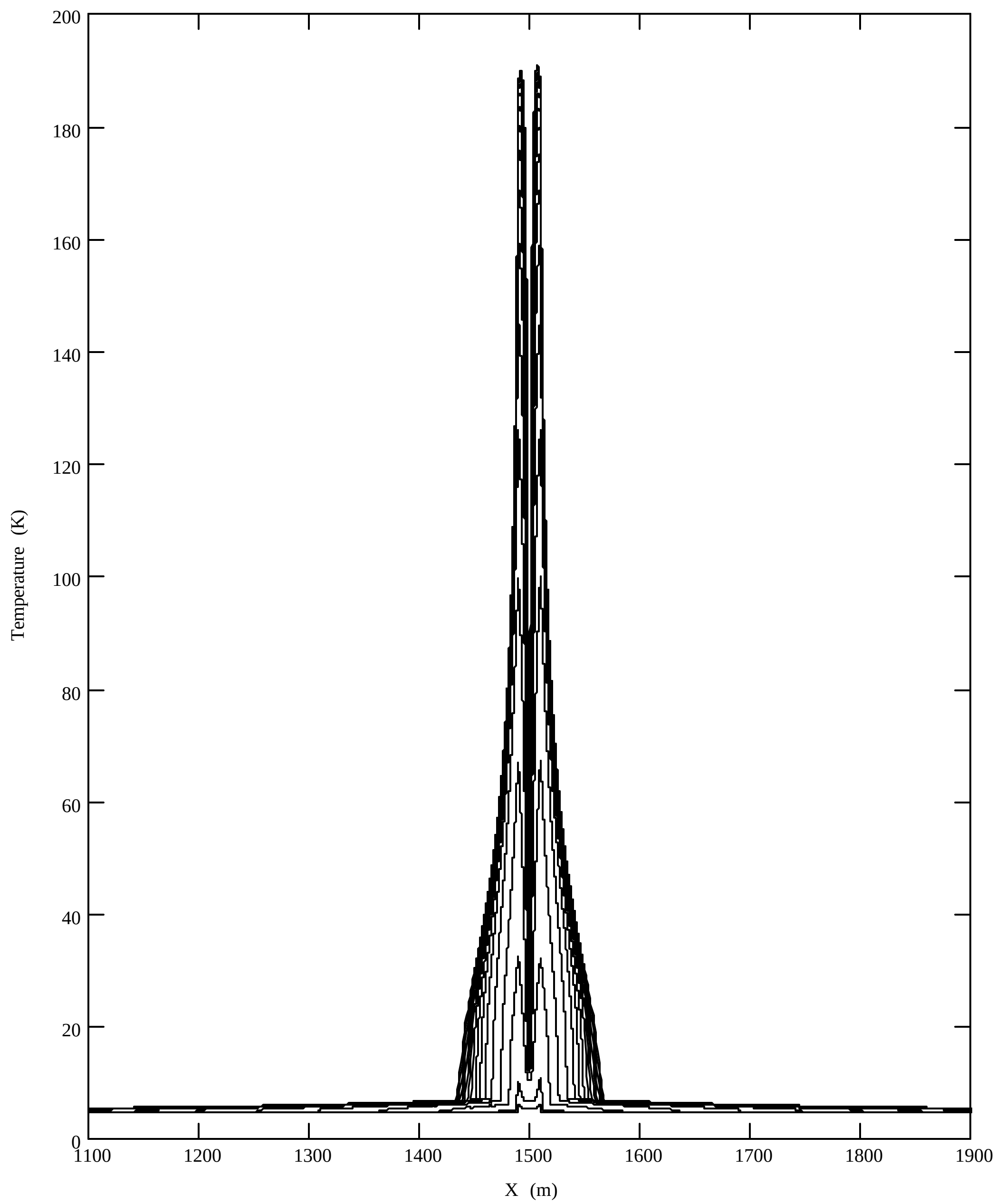


NZ VELOCITY (m/s)
0
50
100
150
200
250
TIME (s)
0
0.5
1
1.5
2
2.5
3
3.5

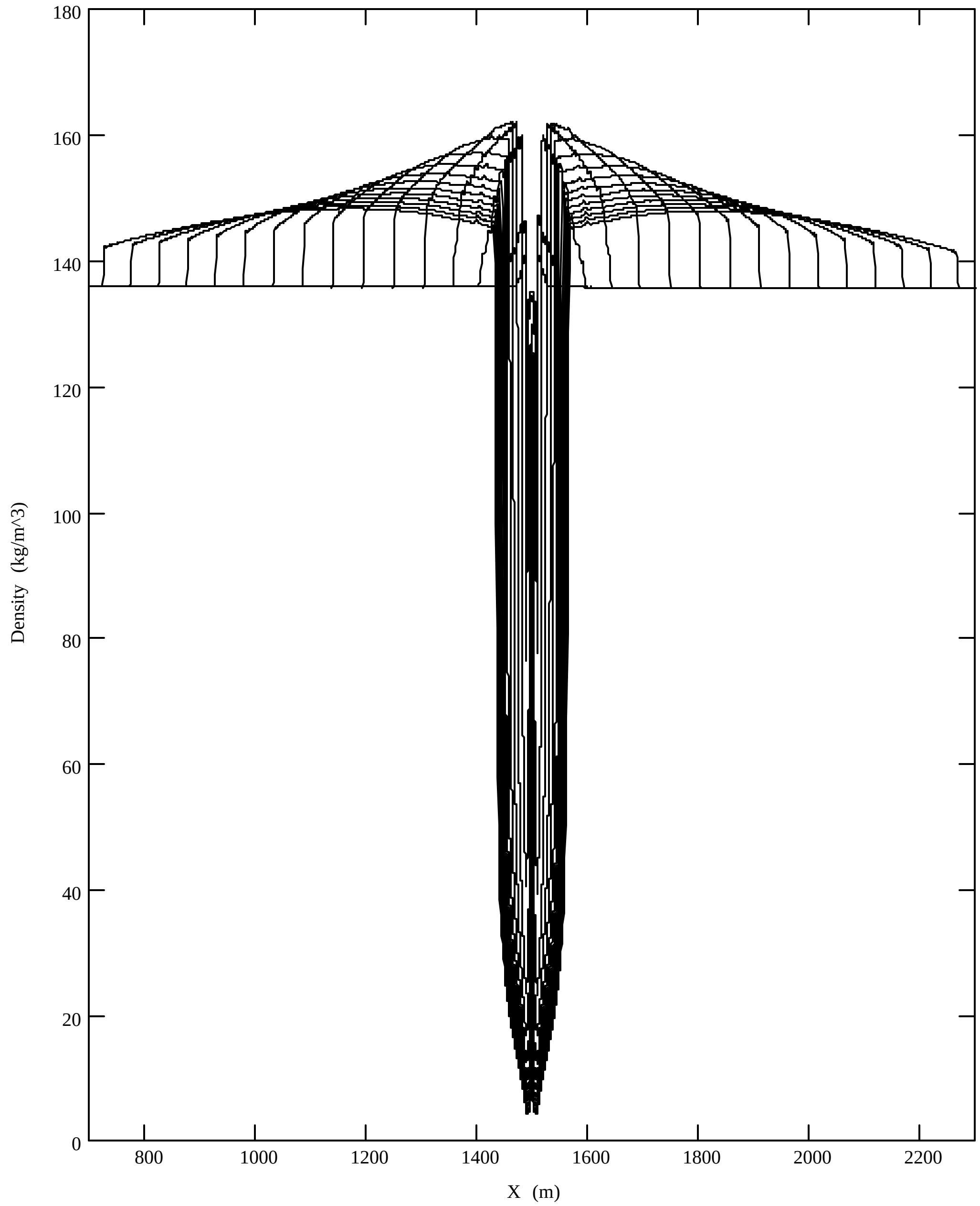
Option 7: L=3000 m, $l_{disturbance}$=20 m (located in the center of conductor with two layers of Rutherford cable)
Initial conditions: P_{in}=5.0 bar, T_{in}=4.6 K, dm / dt=40 g / s, Q_{ext}=0 W / m
Conductor model: conductor is divided into three parts: 1450+100+1450 m. Central part utilizes the 3D model for the inner and outer invar tubes and uses a space step 2 cm (other ones use 1m space step and utilize 1D approach for tubes)



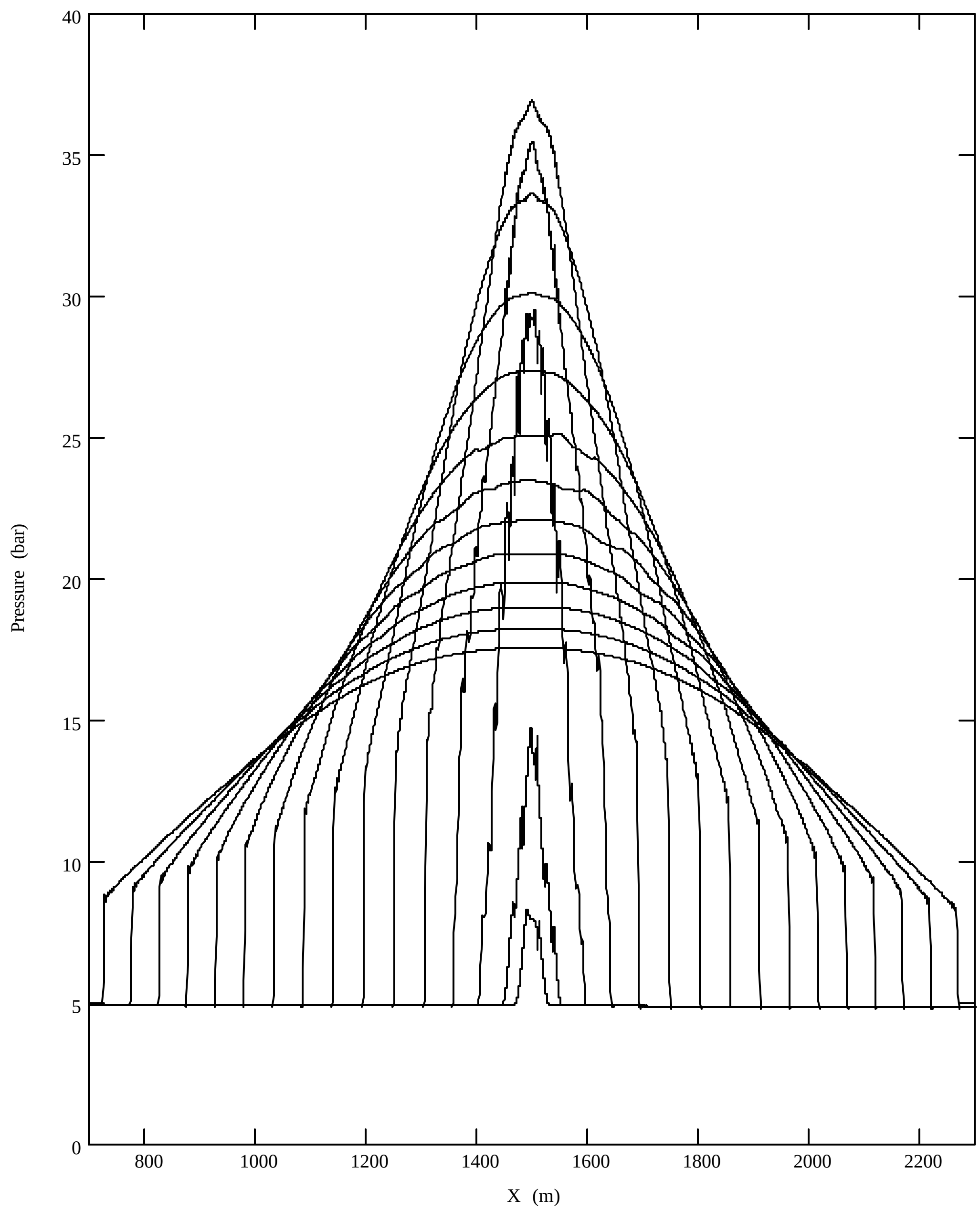
Evolution of the cable temperature. Times: 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0 s.



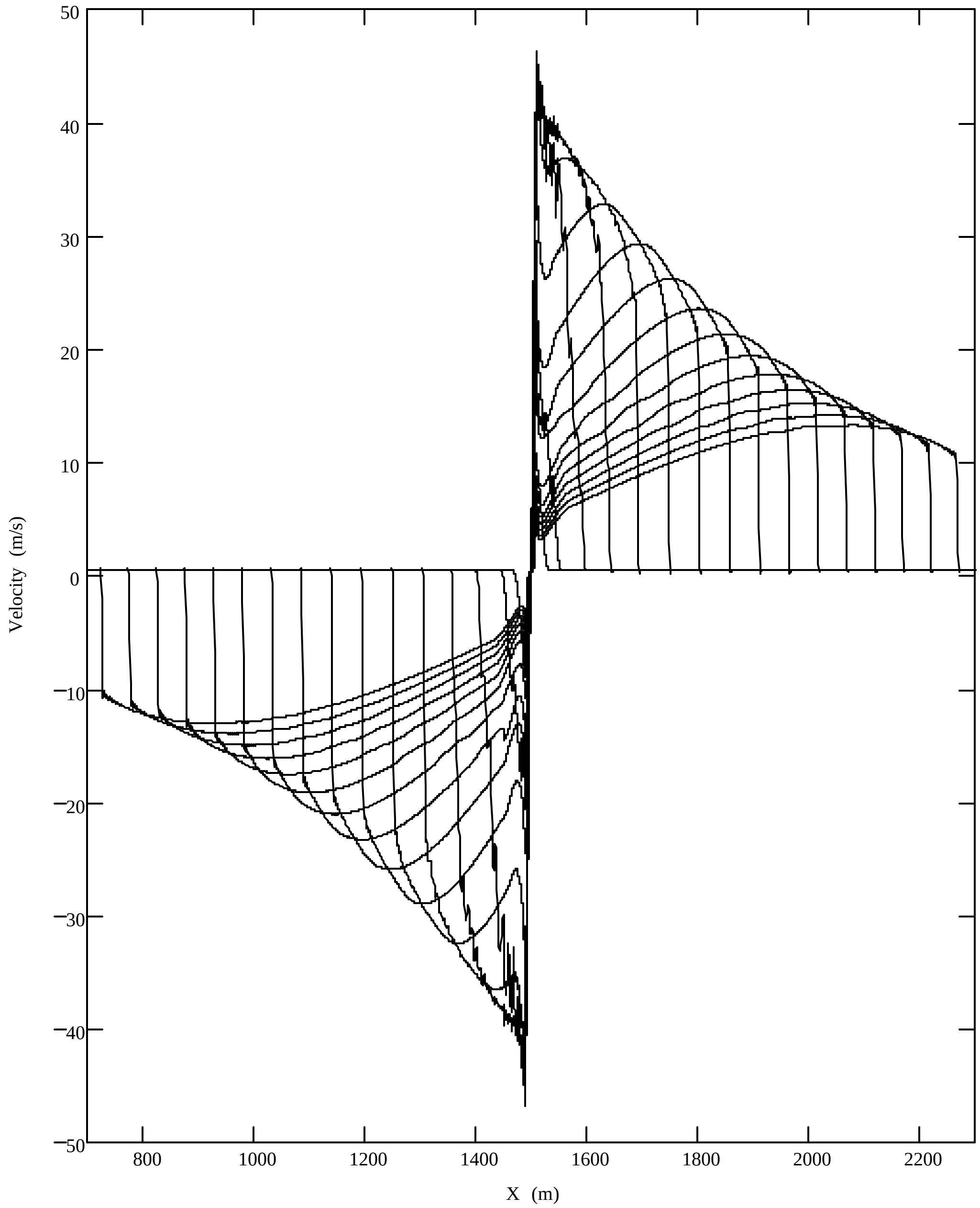
Evolution of the He temperature. Times: 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0 s.



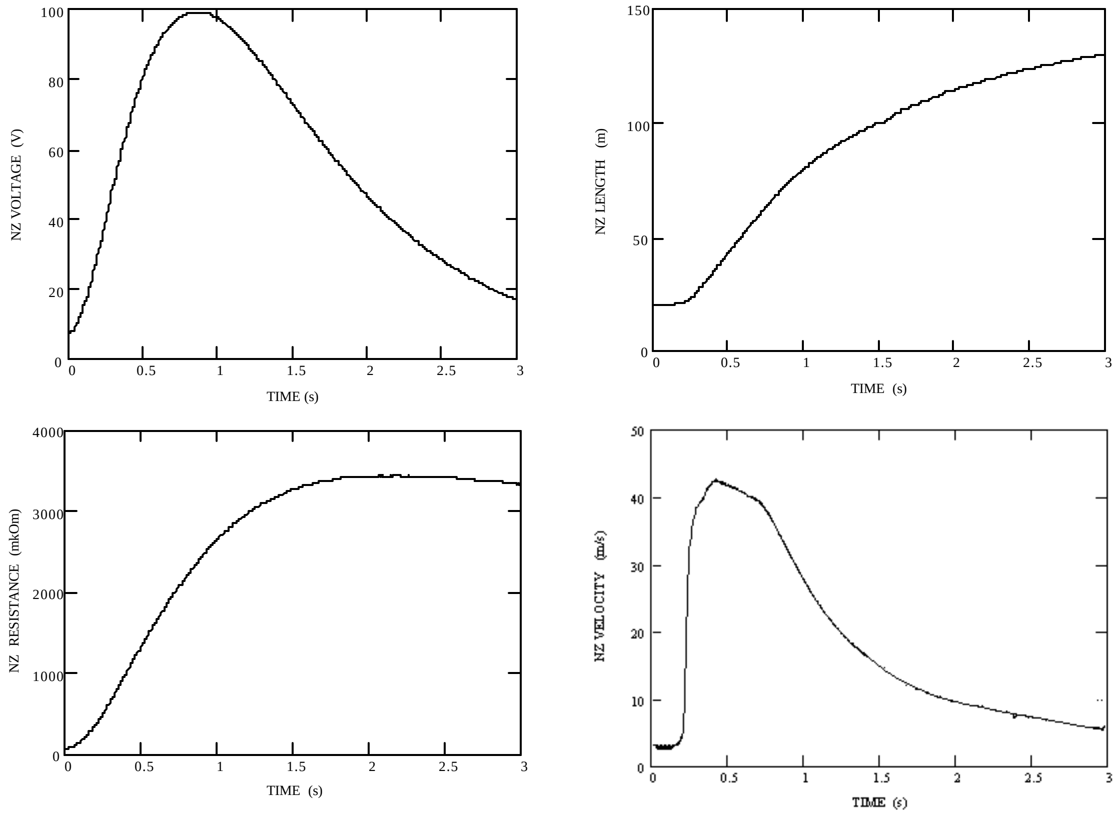
Evolution of the He density. Times: 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0 s.



Evolution of the He pressure. Times: 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0 s.



Evolution of the He velocity. Times: 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0 s.


NZ VOLTAGE (V)
TIME (s)
NZ LENGTH (m)
TIME (s)
NZ RESISTANCE (mkOm)
TIME (s)
NZ VELOCITY (m/s)
TIME (s)